# SEAMAP-SA
# 10-YEAR REPORT

# RESULTS OF TRAWLING EFFORTS IN THE COASTAL HABITAT OF THE SOUTH ATLANTIC BIGHT, FY - 1990-1999

Prepared By

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# INTRODUCTION

The Southeast Area Monitoring and Assessment Program - South Atlantic (SEAMAP-SA) Shallow Water Trawl Survey began in1986, funded by the National Marine Fisheries Service (NMFS) and conducted by the South Carolina Department of Natural Resources - Marine Resources Division (SCDNR-MRD). This survey provides long-term, fishery-independent data on seasonal abundance and biomass of all finfish, elasmobranchs, decapod and stomatopod crustaceans, and cephalopods that are accessible by high-rise trawls. Twenty-three finfish and four decapod species were selected as priority species by the SEAMAP-SA Shallow Water Trawl Committee. Additional data recorded for target species of fishes and decapod crustaceans include measurements of length or width for all priority species and reproductive information on commercially important penaeid shrimp and blue crabs.

Field data collected by the SEAMAP-SA Shallow Water Trawl Survey are available to users within a few weeks of collection. SEAMAP-SA trawl data collected from 1986 to the present are now available through the SEAMAP-SA Data Management Office at NMFS[1]. Management agencies and scientists currently have access to ten years (1990-1999) of comparable trawl data from near-shore coastal areas of the South Atlantic Bight.

This report summarizes ten years of information on species composition, abundance, and biomass from SEAMAP-SA trawls. Length-frequency distributions of twenty-seven commercially and ecologically important species, along with reproductive attributes of the commercially important penaeid species and blue crab, are presented.

[1]Data are available through the SEAMAP Data Manager (NMFS Mississippi Laboratory, P.O. Box 1207, Pascagoula, MS 39568-1207).

## METHODS AND MATERIALS

### Data Collection

Samples were taken by trawl in from the coastal zone of the South Atlantic Bight (SAB) between Cape Hatteras, North Carolina, and Cape Canaveral, Florida (Figure 1). Multi-legged cruises were conducted in spring (mid-April - mid-May), summer (mid-July - early August), and fall (early October - mid-November).

Stations were randomly selected from a pool of trawlable stations within each stratum. The number of stations in each stratum was proportionally allocated according to the total surface area of the stratum. A total of 78 stations were sampled each season (Table 1) within twenty-four inner strata. Inner or shallow strata were delineated by the 4 m depth contour inshore and the 10 m depth contour offshore. Additional stations were sampled in deeper strata with station depths ranging from 10 to 19 m. Twenty-seven stations located within ten outer strata in the southern half of the SAB were sampled only in spring to collect data on spawning of white shrimp. Sixteen stations in the seven outer strata off North Carolina were sampled in fall to gather data on the reproductive condition of brown shrimp. No stations in the outer strata were sampled in summer.

The R/V *Lady Lisa*, a 75-ft (23-m) wooden-hulled, double-rigged, St. Augustine shrimp trawler owned and operated by the South Carolina Department of Natural Resources (SCDNR), was used to tow paired 22.9-m mongoose-type Falcon trawl nets (manufactured by Beaufort Marine Supply; Beaufort, S.C.) without TED's. The body of the trawl was constructed of #15 twine with 1.875-in (47.6-mm) stretch mesh. The cod end of the net was constructed of #30 twine with 1.625-in (41.3-mm) stretch mesh and was protected by chafing gear of #84 twine with 4-in (10-cm) stretch "scallop" mesh. A 300 ft (91.4-m) three-lead bridle was attached to each of a pair of wooden chain doors which measured 10 ft x 40 in (3.0-m x 1.0-m), and to a tongue centered on the head-rope. The 86-ft (26.3-m) head-rope, excluding the tongue, had one large (60-cm) Norwegian float attached top center of the net between the end of the tongue and the tongue bridle cable and two 9-in (22.3-cm) PVC foam floats located one-quarter of the distance from each end of the net webbing. A 1-ft chain drop-back was used to attach the 89-ft foot-rope to the trawl door. A 0.25-in (0.6-cm) tickler chain, which was 3.0-ft (0.9-m) shorter than the combined length of the foot-rope and drop-back, was connected to the door alongside the foot-rope.

Trawls were towed for twenty minutes, excluding wire-out and haul-back time, exclusively during daylight hours (1 hour after sunrise to 1 hour before sunset). Contents of each net were sorted separately to species, and total biomass and number of individuals were recorded for all species of finfish, elasmobranchs, decapod and stomatopod crustaceans, and cephalopods.

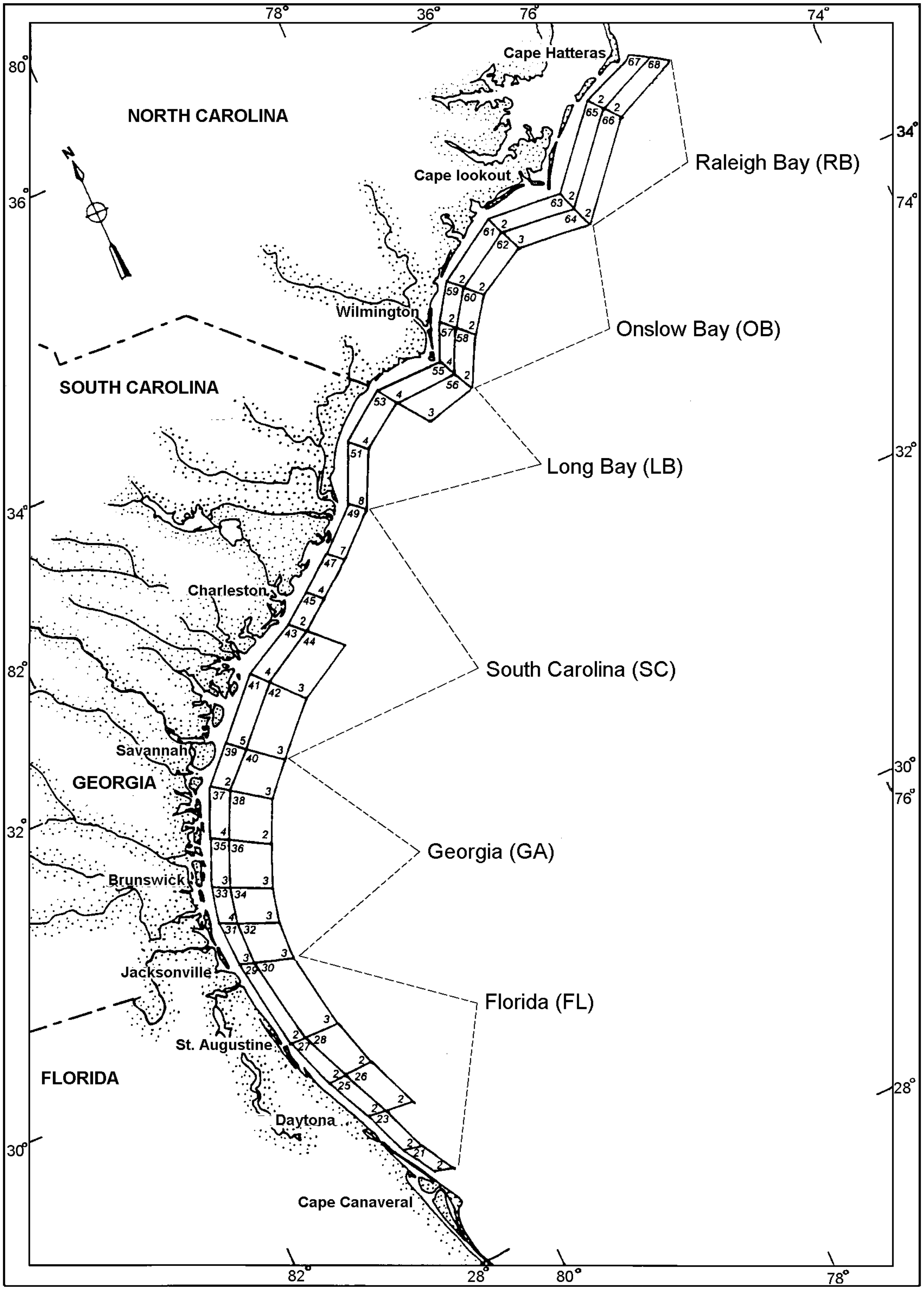



Figure 1. Strata sampled by the SEAMAP-SA Shallow Water Trawl Survey (1990-1999). Stratum number is located in the upper left and number of trawl samples collected in the lower right of each stratum. Strata are not drawn to scale.

Table 1. SEAMAP-SA Shallow Water Trawl Survey effort (number of tows).

**1990**

| | INNER STRATA | | | | OUTER STRATA | |
|---|---|---|---|---|---|---|
| | SPRING | SUMMER | FALL | REGION | SPRING | FALL |
| RB | 4 | 4 | 4 | 12 | | 4 |
| OB | 10 | 10 | 9 | 29 | | 9 |
| LB | 16 | 16 | 16 | 48 | | 3 |
| SC | 22 | 22 | 22 | 66 | 6 | |
| GA | 16 | 16 | 16 | 48 | 14 | |
| FL | 10 | 10 | 8 | 28 | 7 | |
| TOTAL | 78 | 78 | 75 | 231 | 27 | 16 |

**1991**

| | INNER STRATA | | | | OUTER STRATA | |
|---|---|---|---|---|---|---|
| | SPRING | SUMMER | FALL | REGION | SPRING | FALL |
| RB | 4 | 4 | 4 | 12 | | 2 |
| OB | 10 | 10 | 9 | 29 | | 3 |
| LB | 16 | 16 | 16 | 48 | | 4 |
| SC | 22 | 22 | 22 | 66 | 6 | |
| GA | 16 | 16 | 16 | 48 | 14 | |
| FL | 10 | 10 | 10 | 30 | 7 | |
| TOTAL | 78 | 78 | 77 | 233 | 27 | 9 |

**1992-99**

| | INNER STRATA | | | | OUTER STRATA | |
|---|---|---|---|---|---|---|
| | SPRING | SUMMER | FALL | REGION | SPRING | FALL |
| RB | 4 | 4 | 4 | 12 | | 4 |
| OB | 10 | 10 | 10 | 30 | | 9 |
| LB | 16 | 16 | 16 | 48 | | 3 |
| SC | 22 | 22 | 22 | 66 | 6 | |
| GA | 16 | 16 | 16 | 48 | 14 | |
| FL | 10 | 10 | 10 | 30 | 7 | |
| TOTAL | 78 | 78 | 78 | 234 | 27 | 16 |

Only total biomass was recorded for all other miscellaneous invertebrates and algae, which were treated as two separate taxonomic groups. Marine turtles captured incidentally were measured, weighed, tagged, and released according to NMFS permitting guidelines. When large numbers of specimens of a species occurred in a collection, the entire catch was sorted and all individuals of that species were weighed, but only a randomly selected subsample was processed and total number was calculated. For trawl catches where visual estimation of weight of total catch per trawl exceeded 500 kg, the contents of each net were weighed prior to sorting and a randomly chosen subsample of the total catch was then sorted and processed.

In every collection, each of the twenty-seven target species was weighed collectively and individuals were measured to the nearest centimeter (Table 2). For large collections of the target species, a random subsample consisting of thirty to fifty individuals was weighed and measured. Depending on the species, measurements were recorded as total length, fork length, or carapace width. For the penaeid shrimp, *Litopenaeus setiferus*, *Farfantepenaeus aztecus*, and *F. duorarum*, formerly *Penaeus* (Perez-Farfante and Kensley, 1997), total length (mm), sex, female ovarian development, male spermatophore development, and occurrence of mated females were noted. Carapace width (mm), individual weight, sex, and presence and developmental stage of eggs were recorded for *Callinectes sapidus*. Individuals of all shark species were weighed, measured to the nearest centimeter (both total length and fork length), and sex was noted.

Hydrographic data collected at each station included surface and bottom temperature and salinity measurements taken with a CTD profiler, sampling depth, and an estimate of wave height. In addition, atmospheric data on air temperature, barometric pressure, precipitation, and wind speed and direction were also noted at each station.

**Data Analysis**

The SAB was separated into six regions for data analysis (Figure 1). Raleigh Bay (RB), Onslow Bay (OB) and Long Bay (LB) were each considered to be regions. South Carolina, excluding Long Bay (SC), Georgia (GA), and northern Florida (FL) were also treated as separate regions.

Only those data collected in the inner strata are included in general discussions. In depth-zone comparisons, data from outer strata were compared to data from contiguous inner strata sampled during the same season.

Data from the paired trawls were pooled for analysis to form a standard unit of effort (tow). Density estimates, expressed as number of individuals or kilograms per hectare (ha), were standardized by dividing the mean catch per tow by the mean area (ha) swept by the combined trawls. Mean area swept by a net was calculated by multiplying the width of the net opening (13.5 m) as determined by Stender and Barans (1994) by the distance (m) trawled and dividing the product by 10000 $m^2$/ha.

Table 2. Size statistics of target species from all SEAMAP-SA collections (1990-1999).

| FINFISH | MEAN LENGTH (CM) | SIZE EXTREMES (CM) |
|---|---|---|
| *Archosargus probatocephalus* | 44.3 | 18 - 62 |
| *Brevoortia smithi* | 20.0 | 11 - 31 |
| *Brevoortia tyrannus* | 13.8 | 9 - 32 |
| *Centropristis striata* | 16.0 | 5 - 37 |
| *Chaetodipterus faber* | 12.0 | 3 - 42 |
| *Cynoscion nebulosus* | 26.8 | 25 - 30 |
| *Cynoscion regalis* | 19.0 | 3 - 46 |
| *Leiostomus xanthurus* | 16.2 | 5 - 30 |
| *Menticirrhus americanus* | 20.9 | 4 - 48 |
| *Menticirrhus littoralis* | 24.4 | 10 - 44 |
| *Menticirrhus saxatilis* | 24.1 | 8 - 36 |
| *Micropogonias undulatus* | 17.5 | 4 - 34 |
| *Mycteroperca microlepis* | 23.0 | 16 - 32 |
| *Paralichthys albigutta* | 28.1 | 15 - 54 |
| *Paralichthys dentatus* | 24.5 | 8 - 51 |
| *Paralichthys lethostigma* | 30.8 | 13 - 55 |
| *Peprilus alepidotus* | 10.4 | 1 - 21 |
| *Peprilus triacanthus* | 9.4 | 1 - 25 |
| *Pogonias cromis* | 24.5 | 15 - 118 |
| *Pomatomus saltatrix* | 19.2 | 6 - 39 |
| *Sciaenops ocellatus* | 96.0 | 85 - 108 |
| *Scomberomorus cavalla* | 16.2 | 4 - 117 |
| *Scomberomorus maculatus* | 21.7 | 2 - 58 |
| **DECAPOD CRUSTACEANS** | | |
| *Farfantepenaeus aztecus* | 12.1 | 3 - 22 |
| *Farfantepenaeus duorarum* | 11.7 | 6 - 20 |
| *Litopenaeus setiferus* | 14.5 | 4 - 20 |
| *Callinectes sapidus* | 14.1 | 1 - 20 |

Results for priority species are presented and discussed individually in this report. Statistically significant differences in density among years, seasons, and regions, as well as lengths of individuals among season and regions were determined using the non-parametric Kruskal-Wallis test (Sokal and Rohlf, 1981). Contingency tables using the G-statistic were used to determine if occurrence of ripe penaeid shrimp were independent of season and region. Chi-square analysis was used to detect significant deviations from unity of penaeid shrimp sex ratios.

The degree of similarity among strata and among species was determined using normal and inverse cluster analyses, employing the Bray-Curtis similarity index (Boesch, 1977). Species and strata, pooled by region, were classified using flexible sorting with a cluster coefficient ($\beta$) of -0.25. Abundances were logarithmically transformed ($\log_{10}[x+1]$, where x is the number of individuals for a given species).

## RESULTS AND DISCUSSION

### Hydrographic Measurements

Hydrographic patterns of temperature and salinity in the SAB are driven by four major influences which fluctuate seasonally: river run-off, the Gulf Stream, a southerly flowing coastal current, and atmospheric conditions. The warm, highly saline waters of the Gulf Stream, in close proximity to coastal waters off Florida and in Raleigh Bay, elevate temperatures and salinities in those areas (Pietrafesa et al., 1985). Most of the river run-off in the SAB occurs south of Cape Fear (Blanton and Atkinson, 1983; McClain et al., 1988). Water of lower salinity created by freshwater influx is pushed southward by the southerly flowing coastal current; however, this movement is impeded by the northerly flowing Gulf Stream off northern Florida (Blanton, 1981; Blanton and Atkinson, 1983). The result of this process is a concentration of lower salinity water off southern South Carolina and Georgia. Seasonal fluctuations in river run-off, atmospheric conditions, and migrations of the Gulf Stream dictate the magnitudes of these hydrographic patterns.

Typical seasonal and regional patterns of temperature and salinity were observed during the 1990-1999 survey (Table 3), with temperatures and salinities being lower in spring and fall and higher in summer. Temperatures were lowest in the northernmost regions and highest off Georgia and Florida. Highest salinity occurred off Florida, as expected, and lowest occurred off South Carolina and Georgia.

Table 3. Seasonal mean bottom temperatures (°C) and salinities (‰) from each region for 1990-1999. Regions are abbreviated as follows: Raleigh Bay (RB), Onslow Bay (OB), Long Bay (LB), South Carolina (SC), Georgia (GA), and Florida (FL).

| | **RB** | **OB** | **LB** | **SC** | **GA** | **FL** | **ALL REGIONS** |
|---|---|---|---|---|---|---|---|
| **SPRING** | | | | | | | |
| $\bar{X}$ Temperature | 17.8 | 18.0 | 18.1 | 19.3 | 21.9 | 22.9 | 19.8 |
| $\bar{X}$ Salinity | 34.2 | 34.3 | 33.6 | 33.2 | 32.3 | 35.3 | 33.6 |
| **SUMMER** | | | | | | | |
| $\bar{X}$ Temperature | 25.2 | 26.8 | 27.1 | 27.7 | 28.6 | 26.4 | 27.3 |
| $\bar{X}$ Salinity | 36.0 | 35.6 | 35.4 | 34.8 | 35.0 | 36.1 | 35.3 |
| **FALL** | | | | | | | |
| $\bar{X}$ Temperature | 22.6 | 22.2 | 20.9 | 22.1 | 21.7 | 24.0 | 22.0 |
| $\bar{X}$ Salinity | 33.8 | 34.8 | 34.4 | 33.4 | 33.0 | 34.1 | 33.8 |
| **ALL SEASONS** | | | | | | | |
| $\bar{X}$ Temperature | 21.9 | 22.3 | 22.0 | 23.1 | 24.1 | 24.4 | 23.1 |
| $\bar{X}$ Salinity | 34.6 | 34.9 | 34.5 | 33.8 | 33.5 | 35.2 | 34.2 |

## Species Composition

The ten-year sampling effort (1990-1999) resulted in the collection of 322 species (Appendix 1) from both inner and outer strata. Trawls in inner strata produced 296 species of which 182 species were finfish, 30 species were elasmobranchs, 76 species were decapod crustaceans, 4 species were stomatopod crustaceans, and 4 genera were cephalopods. Outer strata produced a total of 272 species, 163 of which were finfish, 22 were elasmobranchs, 81 were decapods, 3 were stomatopod, and 3 genera were cephalopods.

The number of species varied little seasonally among inner strata (Appendix 2), although the number did increase slightly from spring to fall. Regionally, the greatest number of species was found in Long Bay, with the number of species decreasing north and southward.

## Regional Groupings and Species Assemblages

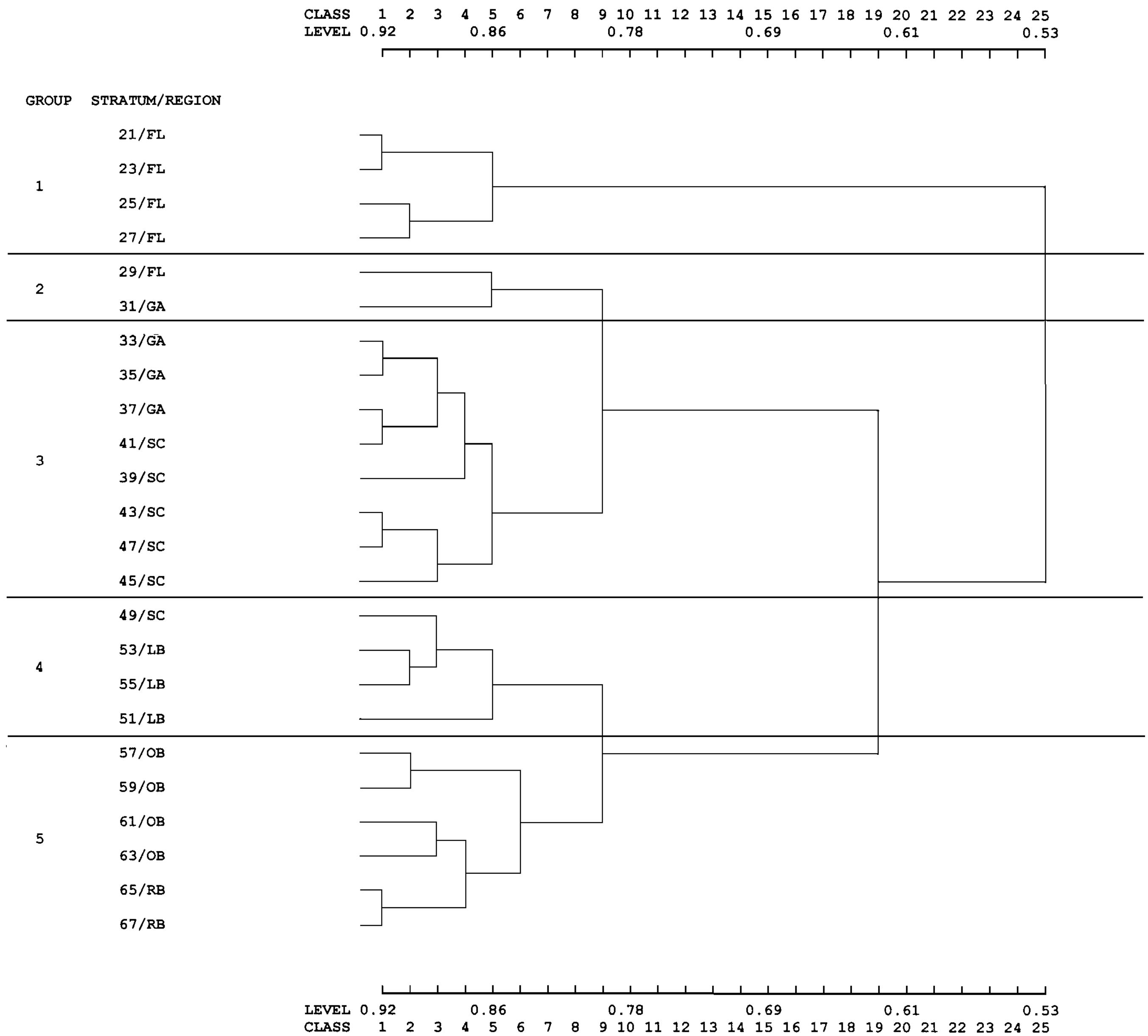
### Inner strata

Five strata groups representing different areas of the inner depth-zone of the SAB were formed by normal cluster analysis of samples taken during all seasons and all years and pooled by strata (Figure 2). Group 1, the regional grouping most dissimilar to the remaining four, included the southernmost strata in the SAB ranging from Cape Canaveral, Florida north to the St. John's River. Group 2 comprised only two strata, located off northern Florida and southern Georgia. Group 3, the largest group, included eight strata that extended from waters off Cumberland Island, Georgia, north to Bull's Bay in South Carolina waters. Group 4 comprised strata from waters off the northern portion of South Carolina and Long Bay, extending from Winyah Bay in South Carolina north to the Cape Fear River in North Carolina. Group 5 included the six northernmost strata, including all of Onslow and Raleigh Bays.

For data analysis the SAB has historically been separated into six geographical regions (Raleigh Bay, Onslow Bay, Long Bay, South Carolina, Georgia, and Florida. As the result of cluster analysis, only five regions were identified: Raleigh and Onslow Bays combined to form a single region, Long Bay (the region that has always produced the greatest number of species), South Carolina and Georgia combined, southern Georgia and northern Florida (a transitional zone characterized by a narrowing of the inner depth-zone), and the remainder of Florida strata (Figure 3).

Inverse cluster analysis resulted in the formation of thirteen species groups (Table 4). Groups A through E contained species whose center of abundance was located in the northern SAB, with few individuals taken in the southern strata. Group A consisted of two species that were most abundant (>80% ) in regional group 5 (Raleigh and Onslow Bays). Group B consisted of five species or genera, all of which were most abundant in regional groups 5 and 4 (Raleigh, Onslow, and Long Bays and one stratum off Winyah Bay in South Carolina). The two species in Group C were rarer

Figure 2. Normal cluster dendrogram of samples pooled by strata from the inner depth-zone in the South Atlantic Bight. Strata within each group are identified by stratum number (refer to Figure 1) and region (FL=Florida, GA=Georgia, SC=South Carolina, LB=Long Bay, OB=Onslow Bay, RB=Raleigh Bay).



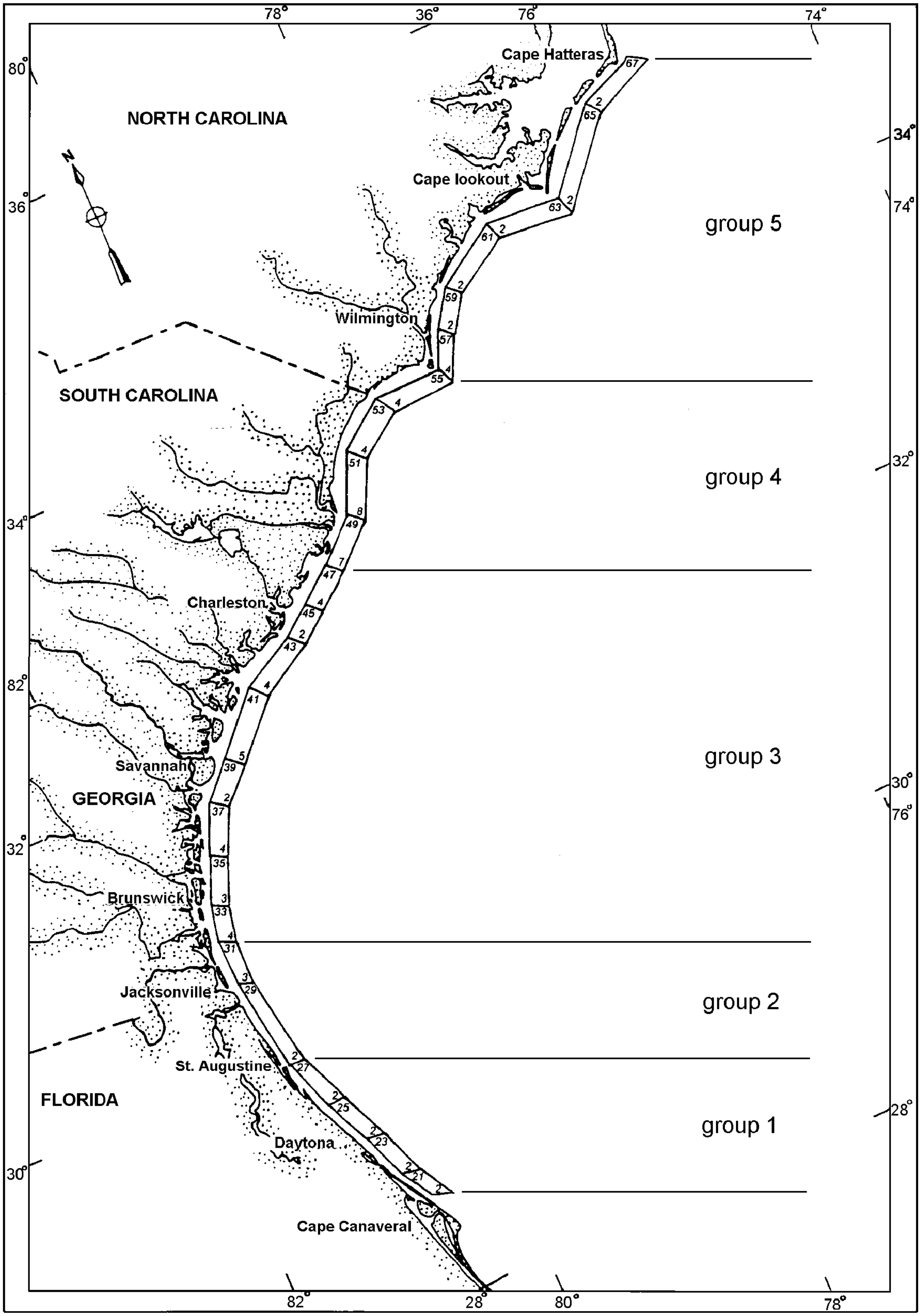



Figure 3. Regional groups representing different areas of the inner depth-zone of the SAB formed by normal cluster analysis of samples taken during all seasons and all years and pooled by strata.

Table 4. Species groups identified by inverse cluster dendrogram analysis of samples pooled by strata from inner strata in the South Atlantic Bight.

Group A
Menticirrhus saxatilis
Mustelus canis

Group B
Archosargus probatocephalus
Centropristis striata
Decapterus punctatus
Sphoeroides maculatus
Stenotomus sp.

Group C
Calamus leucosteus
Haemulon aurolineatum

Group D
Acanthostracion quadicornis
Cancer irroratus
Pilumnus sayi

Group E
Chaetodon ocellatus

Group F
Anchoa hepsetus
Anchoa lyolepis
Anchoa mitchilli
Ancylopsetta quadrocellata
Brevoortia tyrannus
Callinectes similis
Caranx crysos
Centropristis philadelphica
Chaetodipterus faber
Chloroscombrus chrysurus
Citharichthys macrops
Cynoscion nothus
Cynoscion regalis
Etropus crossotus
Eucinostomus sp.
Farfantepenaeus aztecus
Loligo sp.
Lolliguncula brevis
Larimus fasciatus
Leiostomus xanthurus
Litopenaeus setiferus

Group F (continued)
Menticirrhus americanus
Micropogonias undulatus
Opisthonema oglinum
Ovalipes ocellatus
Ovalipes stephensoni
Peprilus alepidotus
Peprilus triacanthus
Portunus gibbesii
Portunus spinimanus
Prionotus carolinus
Prionotus evolans
Prionotus rubio
Prionotus scitulus
Prionotus tribulus
Rhizoprionodon terraenovae
Scomberomorus cavalla
Scomberomorus maculatus
Selene setapinnis
Selene vomer
Spyraena guachancho
Synodus foetens
Trichiurus lepturus

Group G
Dasyatis sayi
Etropus cyclosquamus
Lagodon rhomboides
Monacanthus hispidus
Myliobatis freminvillei
Orthopristis chrysoptera
Raja eglanteria
Rhinoptera bonasus

Group H
Callinectes sapidus
Chilomycterus schoepfi
Dasyatis americana
Dasyatis sabina
Etrumeus teres
Farfantepenaeus duorarum
Paralichthys dentatus
Pomatomus saltatrix
Scophthalmus aquosus
Urophycis regius

Group I
Menippe mercenaria
Neopanope sayi
Pagurus longicarpus
Porcellana sigsbeiana
Rimapenaeus constrictus
Urophycis floridanus
Xiphopenaeus kroyeri

Group J
Alectis ciliarius
Aluterus schoepfi
Calappa flammea
Echeneis naucrates
Lutjanus synagris
Sardinella aurita

Group K
Arius felis
Bagre marinus
Sphyrna tiburo

Group L
Arenaeus cribrarius
Caranx hippos
Gymnura micrura
Harengula jaguana
Menticirrhus littoralis
Paralichthys albigutta
Trachinotus carolinus

Group M
Alosa aestivalis
Brevoortia smithi
Mobula hypostoma

species that were completely absent from tows made in the southern SAB. Group D contained three species that were most numerous in regional group 4 (primarily Long Bay), and Group E included a single species collected almost exclusively in regional group 4 (Long Bay). Group F was the group made up of the largest number of species or genera. The species in this group are ubiquitous, found throughout the SAB, and generally exhibited a high frequency of occurrence in SEAMAP-SA trawls. Groups G and H also contained species collected throughout the SAB, but the frequency of occurrence of the species in those two groups was generally much lower than those found in Group F. Group G comprised species that were most abundant in regional groups 3, 4, and 5 (north of Cumberland Island, Georgia) and least abundant in regional group 2 (northern Florida and southern Georgia). Group H was made up of species that were most abundant in regional groups 3 and 4 (from Cumberland Island, Georgia, north to the Cape Fear River in North Carolina) and least abundant in regional group 1 (Florida waters south of Jacksonville). Like Group H, Group I consisted of species most abundant in regional group3 and 4 and least abundant in group 1, but exhibited low frequencies of occurrence and were frequently found in live bottom areas of Long Bay. Group J contained species most abundant in regional groups 3 and 4 (from Cumberland Island, Georgia, north to the Cape Fear River in North Carolina) and least abundant in regional group 2 (northern Florida and southern Georgia).Group K consisted of species which occurred throughout the SAB, but whose center of abundance was in the southern SAB, with decreasing abundance northward. Group L comprised those species most abundant in regional group 1 (strata off Florida below Jacksonville) and least abundant in regional group 2 (northern Florida and southern Georgia). Group M also contained species most abundant in regional group 1 (strata off Florida below Jacksonville) and least abundant in regional group 4 (Long Bay).

**Comparison of inner and outer strata from spring samples**

Comparable depth-zone strata from the southern portion of the SAB (Figure 1) sampled during the spring cruises (1990-1999) were divided into four regional groups by normal cluster analysis of the samples pooled by strata (Figure 4). Regional group 1 included most of the comparable strata off Florida and included strata from both depth-zones, probably due to the fact that outer strata off Florida off are so close to shore. Regional group 2 comprised only three outer strata, two contiguous strata from waters off northern Florida and southern Georgia and an additional stratum located in northern Georgia. Among the strata sampled in spring in both depth-zones, Group 3 was the largest group, containing eight strata, all of which were inner strata except one and ranged from southern Georgia to the northernmost comparable strata sampled in spring. Group 4 included only outer strata from waters off Georgia and South Carolina.

Inverse cluster analysis resulted in the formation of eleven species groups from spring collections made in comparable depth-zones in the southern SAB (Table 5). Groups A and B contained species of relatively low abundance taken only in inner strata. Group A contained three species that were restricted to regional group 3 (southern Georgia to waters off Charleston, South Carolina), whereas Group B included three species taken in inner strata off Florida as well.

Figure 4. Normal cluster dendrogram of samples pooled by strata from outer strata sampled during spring cruises in the southern portion of the South Atlantic Bight. Strata within each group are identified by stratum number (**STR**: refer to Figure 1), region (**REG**: FL=Florida, GA=Georgia, SC=South Carolina, LB=Long Bay, OB=Onslow Bay, RB=Raleigh Bay), and depth-zone (**ZONE**: I=Inner, O=Outer).

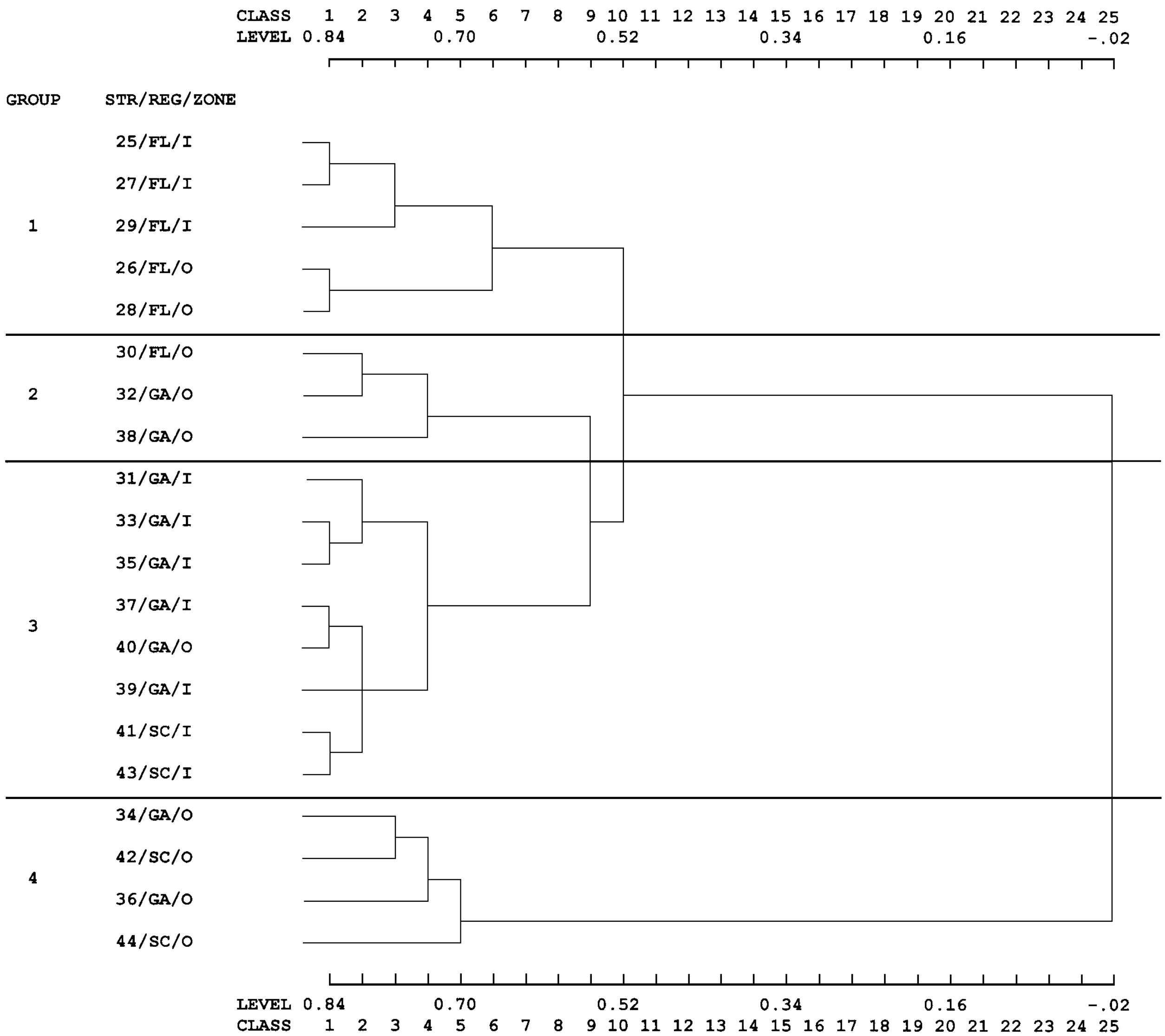


Table 5. Species groups identified by inverse cluster dendrogram analysis of samples pooled by strata from comparable strata from both depth-zones sampled during spring cruises in the southern portion of the South Atlantic Bight.

Group A
Cancer irroratus
Menippe mercenaria
Mustelus canis

Group B
Archosargus probatocephalus
Dasyatis sabina
Xiphopenaeus kroyeri

Group C
Alosa aestivalis
Arenaeus cribrarius
Bagre marinus
Brevoortia smithi
Brevoortia tyrannus
Caranx crysos
Farfantepenaeus aztecus
Gymnura micrura
Menticirrhus littoralis
Micropogonias undulatus
Paralichthys albigutta
Paralichthys lethostigma
Prionotus evolans
Selene setapinnis
Selene vomer
Sphyraena guachancho
Sphyrna tiburo
Trachinotus carolinus
Trichiurus lepturus
Trinectes maculatus

Group D
Centropristis philadelphica
Citharichthys spilopterus
Eucinostomus sp.
Selar crumenophthalmus

Group E
Callinectes ornatus
Caranx hippos
Harengula jaguana
Lutjanus synagris
Mobula hypostoma
Menticirrhus saxatilis

Group F
Anchoa hepsetus
Anchoa lyolepis
Anchoa mitchilli
Ancylopsetta quadrocellata
Arius felis
Bairdiella chrysoura
Callinectes sapidus
Callinectes similis
Calappa flammea
Chaetodipterus faber
Chilomycterus schoepfi
Chloroscombrus chrysurus
Citharichthys macrops
Cynoscion nothus
Cynoscion regalis
Dasyatis americana
Dasyatis sayi
Group F (cont'd)
Echeneis naucrates
Etropus crossotus
Etropus cyclosquamus
Etrumeus teres
Farfantepenaeus duorarum
Hepatus epheliticus
Larimus fasciatus
Lagodon rhomboides
Leiostomus xanthurus
Libinia dubia
Libinia emarginata
Litopenaeus setiferus
Loligo sp.
Lolliguncula brevis
Menticirrhus americanus
Monacanthus hispidus
Myliobatis fremenvillei
Neopanope sayi
Opisthonema oglinum
Orthopristis chrysoptera
Ovalipes ocellatus
Ovalipes stephensoni
Pagurus pollicaris
Pagurus longicarpus
Paralichthys dentatus
Peprilis alepidotus

Group F (cont'd)
Peprilis triacanthus
Persephona mediterranea
Pomatomus saltatrix
Porcellana sigsbeiana
Portunus gibbesii
Portunus spinimanus
Prionotus carolinus
Prionotus rubio
Prionotus tribulus
Raja eglanteria
Rhinoptera bonasus
Rhizoprionodon terraenovae
Rimapenaeus constrictus
Sardinella aurita
Scomberomorus cavalla
Scomberomorus maculatus
Scopththalmus aquosus
Squilla empusa
Squilla neglecta
Sphoeroides maculatus
Stellifer lanceolatus
Symphurus plagiusa
Synodus foetens
Urophycis floridanus
Urophycis regius

Group G
Acanthostracion quadricornis
Aluterus schoepfi
Dasyatis centroura
Decapterus punctatus
Diplectrum formosum
Dromidia antillensis
Hemipteronotus novacula
Hippocampus erectus
Octopus vulgaris
Pagurus impressus
Petrochirus diogenes
Pilumnus sayi
Prionotus scitulus
Scomber japonicus
Scorpaena calcarata
Seriola zonata
Sicyonia brevirostris
Sicyonia laevigata
Stenotomus sp.
Syacium papillosum
Trachinocephalus myops
Trachurus lathami

Group H
Bothus robinsi
Rachycentron canadum
Upeneus parvus

Group I
Balistes capriscus
Centropristis striata
Haemulon aurolineatum
Lagocephalus laevigata

Group J
Calamus leucosteus
Halichoeres bivittata
Halichoeres caudalis
Podochela riisei

Group C comprised twenty species that were taken throughout the southern portion of the SAB only in inner strata and in outer strata off Florida. Group D included four species that were most abundant in outer strata off Florida., whereas the six species in Group E were most abundant in inner strata off Florida. Group F was the largest species group, containing sixty-eight species ranging throughout the southern SAB in both depth-zones. Generally, species included in group F were ubiquitous species of high to moderate abundance. Groups G through J contained species that were lower in abundance. Group G was made up of twenty-two species that were collected throughout the southern SAB, but were most abundant in outer strata, especially off Georgia and South Carolina (regional group 4). Group H contained three species taken only in outer strata throughout the range. Group I comprised four species taken mostly in outer strata off Georgia and South Carolina. The four species in Group J were relatively rare species taken exclusively in regional group 4 (outer strata off Georgia and South Carolina.).

**Comparison of inner and outer strata from fall samples**

Depth-zone comparisons from fall cruises (1990-1999) in the northern portion of the SAB resulted in five regional groups formed by normal cluster analysis of samples pooled by strata (Figure 5). Group 1 included all of the inner strata sampled among comparable strata. Only outer strata made up regional Groups 2 through 5. Groups 2 and 4 each contained a single stratum, both situated near Frying Pan shoals near the Cape Fear River. Group 2 included the only outer stratum in Long Bay and Group 4 is made up of the outer stratum on the eastern side of the shoals in Onslow Bay. Group 3 included the outer strata in Raleigh Bay and Group 5 those outer strata in northern Onslow Bay.

Inverse cluster analysis resulted in the formation of ten species groups from comparable depth-zones in the northern SAB in fall (Table 6). Group A contained species of relatively low abundance which were taken almost exclusively in inner strata and primarily in Raleigh Bay. Group B included a single decapod crustacean species collected only in outer strata in Onslow Bay. Group C contained species that were collected primarily in inner strata south of Cape Lookout. Group D included species found in all strata, both inner and outer. Group E contained the largest number of species, many of which were numerically dominant, found in both depth-zones, but most abundant in inner strata, especially in the four northernmost strata (Cape Lookout and above). Group F consisted of species taken only in inner strata. Group G was made up of species of relatively low abundance taken exclusively in outer strata, primarily around the shoals in Long and Onslow Bays. Group H comprised species taken only in outer strata, mainly in Raleigh Bay. Group I contained species taken exclusively in outer strata throughout the comparable strata sampled in fall. Species in Group J were found in most of the northern strata, both inner and outer, but were most abundant in outer strata.

Strata sampled in both inner and outer different depth-zones exhibited differences in species composition and abundance. As the result of cluster analysis, comparable inner strata sampled in the northern SAB in fall were identified as a group completely separate from all outer strata in the northern SAB. The same occurred in the southern SAB among comparable strata sampled in spring, with the exception of strata off Florida where the inner depth-zone is so narrow that outer strata are very close to shore and, therefore, indistinguishable from inner strata.

Figure 5. Normal cluster dendrogram of samples pooled by strata from outer strata sampled during fall cruises in the northern portion of the South Atlantic Bight. Strata within each group are identified by stratum number (**STR**: refer to Figure 1), region (**REG**: FL=Florida, GA=Georgia, SC=South Carolina, LB=Long Bay, OB=Onslow Bay, RB=Raleigh Bay), and depth-zone (**ZONE**: I=Inner, O=Outer).

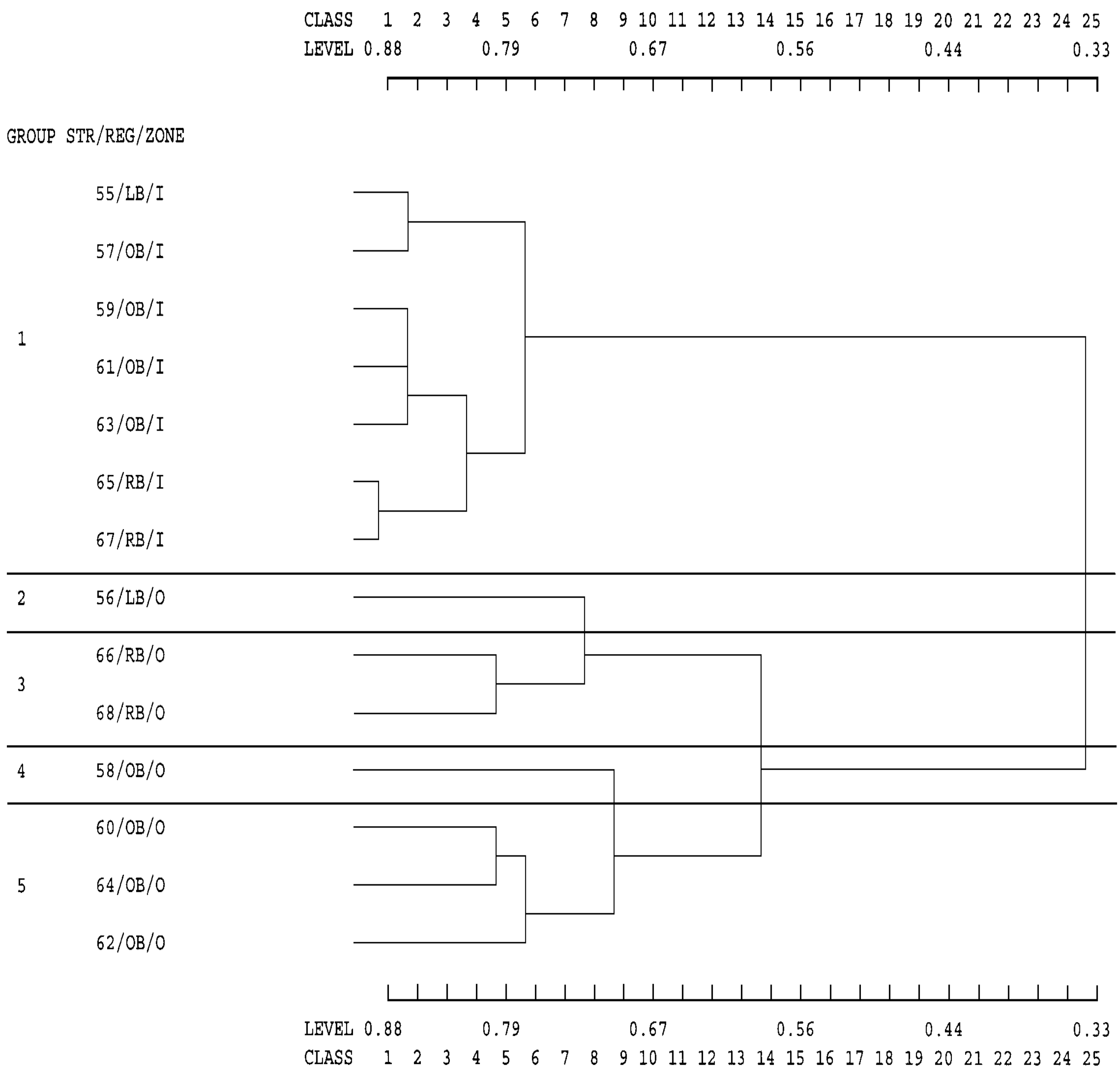


Table 6. Species groups identified by inverse cluster dendrogram analysis of samples pooled by strata from comparable strata from both depth-zones sampled during fall cruises in the northern portion of the South Atlantic Bight.

Group A
Echeneis naucrates
Mustelus canis
Urophycis floridanus
Urophycis regius

Group B
*Pagurus longicarpus*

Group C
Alectus ciliarius
Arius felis
Bagre marinus
Brevoortia smithi
Chaetodon ocellatus
Etrumeus teres
Harengula jaguana
Lutjanus synagris
Menippe mercenaria
Neopanope sayi
Persephona mediterranea
Porcellana sigsbeiana
Rimapenaeus constructus
Trinectes maculatus

Group D
Anchoa hepsetus
Ancylopsetta quadrocellata
Calappa flammea
Centropristis striata
Chaetodipterus faber
Chilomycterus schoepfi
Decapterus punctatus
Diplectrum formosum
Etropus cyclosquamus
Lagodon rhomboides
Loligo sp.
Monacanthus hispidus
Orthopristis chrysoptera
Ovalipes stephensoni
Paralichthys albigutta
Prionotus carolinus
Prionotus evolans
Prionotus rubio
Prionotus scitulus
Prionotus tribulus
Rhizoprionodon terraenovae
Sardinella aurita
Scophthalmus aquosus
Sphoeroides maculatus
Stenotomus sp.
Syacium papillosum
Synodus foetens

Group E
Anchoa lyolepis
Anchoa mitchilli
Arenaeus cribrarius
Bairdiella chrysoura
Callinectes sapidus
Callinectes similis
Caranx crysos
Centropristis philadelphica
Chloroscombrus chrysurus
Citharichthys macrops
Citharichthys spilopterus
Cynoscion nothus
Cynoscion regalis
Dasyatis americana
Dasyatis sayi
Etropus crossotus
Eucinostomus sp.
Farfantepenaeus aztecus
Farfantepenaeus duorarum
Hepatus epheliticus
Larimus fasciatus
Leiostomus xanthurus
Libinia emarginata
Litopenaeus setiferus
Lolliguncula brevis
Menticirrhus americanus
Menticirrhus littoralis
Menticirrhus saxatilis
Myliobatis freminvellei
Opisthonema oglinum
Ovalipes ocellatus
Paralichthys dentatus
Paralichthys lethostigma
Peprilus alepidotus
Peprilus triacanthus
Pomatomus saltatrix
Portunus gibbesii
Portunus spinimanus
Raja eglanteria
Rhinoptera bonasus
Scomberomorus cavalla
Scomberomorus maculatus
Selene setapinnis
Selene vomer
Sphyraena guachancho
Squilla empusa
Squilla neglecta
Stellifer lanceolatus
Symphurus plagiusa
Trichiurus lepturus

Group F
Archosargus probatocephalus
Brevoortia tyrannus
Callinectes ornatus
Caranx hippos
Dasyatis sabina
Gymnura micrura
Libinia dubia
Pagurus pollicaris
Trachinotus carolinus
Xiphopenaeus kroyeri

Group G
Dromidia antillensis
Scomber japanicus
Sphyrna tiburo

Group H
Gymnura altavela
Lagocephalus laevigata
Selar crumenophthalmus
Trachurus lathami
Upeneus parvus

Group I
Ariomma regulus
Balistes capriscus
Bothus robinsi
Dasyatis centroura
Hemipteronotus novacula
Hippocampus erectus
Pagurus impressus
Rachycentron canadum
Scorpaena calcarata
Seriola zonata
Sicyonia brevirostris
Trachinocephalus myops

Group J
Acanthostracion quadricornis
Aluterus schoepfi
Calamus leucosteus
Haemulon aurolineatum
Halichoeres bivattata
Halichoeres caudalis
Octopus vulgaris
Petrochirus diogenes
Pilumnus sayi

## Abundance, Biomass, and Density Estimates

Total catch for all inner and outer strata from the 10-year survey was 3,521,085 individuals with a biomass of 384,252 kg. Inner strata yielded 3,096,458 specimens (1326 individuals/tow) and 341,677 kg (146.3 kg/tow). The overall density of individuals for inner strata (345 individuals/ha) represents abundance levels which varied annually (Figure 6).

Patterns of abundance in the SAB generally reflect the abundance of two members of the sciaenid family, the spot, *Leiostomus xanthurus*, and the Atlantic croaker, *Micropogonias undulatus*, which have been consistent in their numerical dominance among years. These two species constituted more than 36% of the total catch during the 10-year period. Spot, *Leiostomus xanthurus*, was the numerically dominant species, the Atlantic croaker, *Micropogonias undulatus*, ranked second, and the Atlantic bumper, *Chloroscombrus chrysurus*, ranked third. The white shrimp, *Litopenaeus setiferus*, ranked sixth overall and was the most abundant decapod crustacean collected, followed by the brown shrimp, *Farfantepenaeus aztecus*, and the portunid crab, Portunus gibbesii. Excluding miscellaneous invertebrates and algae, the cow nose ray, *Rhinoptera bonasus*, ranked third in biomass, after spot and Atlantic croaker.

Six of the priority finfish species were rare (constituting less than 0.01% of total catch) in SEAMAP-SA trawls. Those species include *Archosargus probatocephalus*, *Cynoscion nebulosus*, *Mycteroperca microlepis*, *Paralichthys albigutta*, *Pogonias cromis,* and *Sciaenops ocellatus.*

Density of individuals peaked in 1990-1992, followed by a drop in 1993 to the lowest level of overall abundance observed in the history of the survey (Figure 6). The low abundance found in 1993 was attributed to the large biomass of miscellaneous invertebrates, especially jellyfish, that frequently filled and clogged nets, thereby excluding other species from collections. Densities of individuals and biomass in the inner depth-zone were highest in spring and fall and lowest in summer (Appendix 2).

The highest regional density of individuals and biomass occurred in Raleigh Bay, reflecting relatively large catches of sciaenids, with density decreasing southward to Georgia. The second highest density occurred in waters off Florida. Georgia and South Carolina had the lowest densities of individuals and biomass, due primarily to the absence of spot and Atlantic croaker in many tows.

Outer strata produced fewer specimens than those in the inner depth-zone, with a total of 424,627 individuals and 1004 individuals/tow (spring: 259,591 individuals, 232 individuals/ha; fall: 175,036 individuals, 296 individuals/ha). Abundance in the outer depth-zone was generally lower than that found in more shallow strata; however, abundance from spring trawls in the southern SAB was sometimes quite high (Figure 7), a phenomenon which may be attributed to the fact that outer strata off Florida are much closer to shore than are other outer strata. Although spot and Atlantic croaker were numerically important in the outer depth-zones in both seasons, they played a less dominant role in the outer strata, especially in fall off North Carolina where depth-zone differences were more apparent. In fall collections in the northern SAB, *Stenotomus* sp. was the most abundant taxon in outer strata, its abundance greater than the combined abundance of all target species sampled in outer strata. Other species of importance in outer strata included *Loligo* spp., *Synodus foetens,* and *Larimus fasciatus.*.

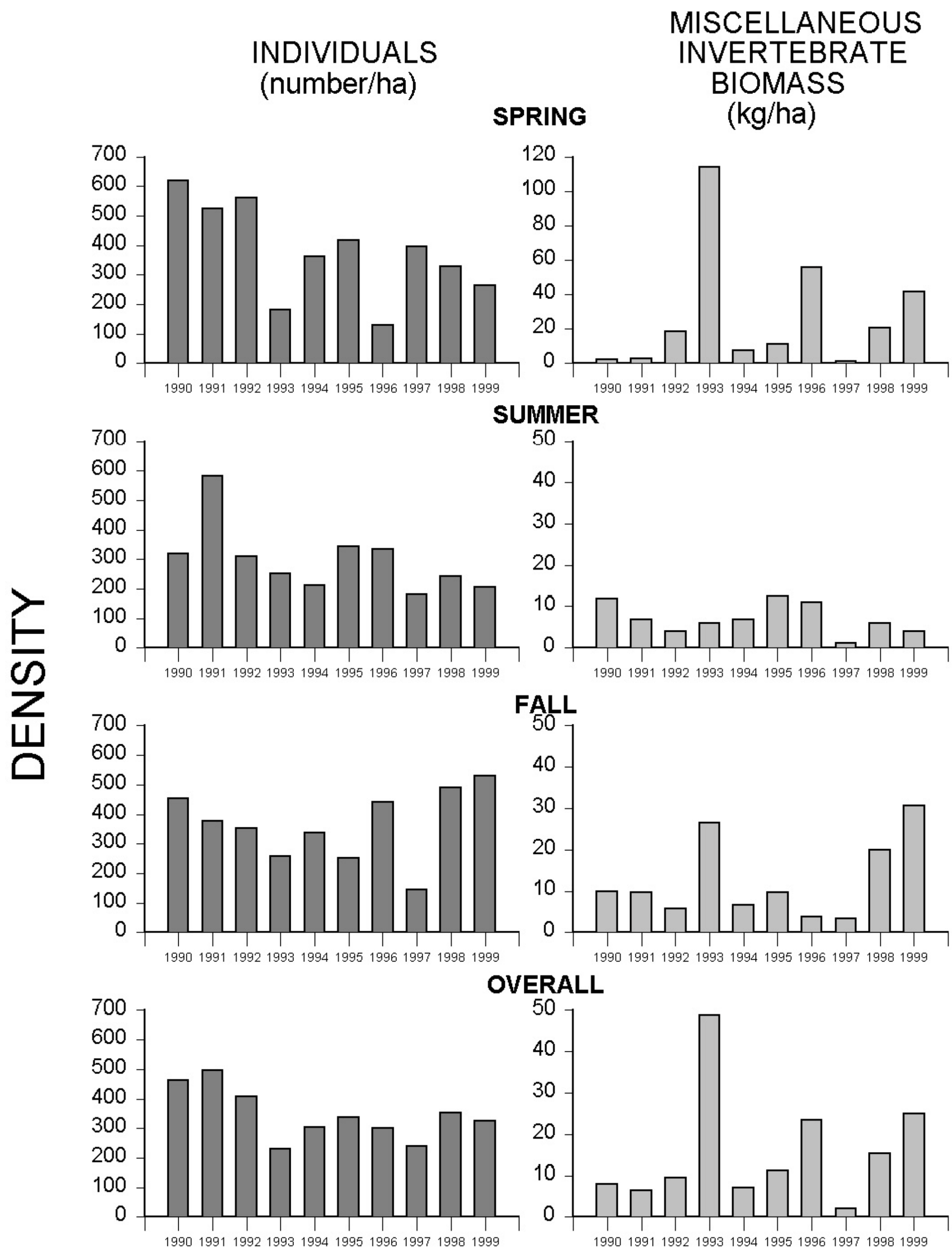



Figure 6. Annual densities from inner strata.

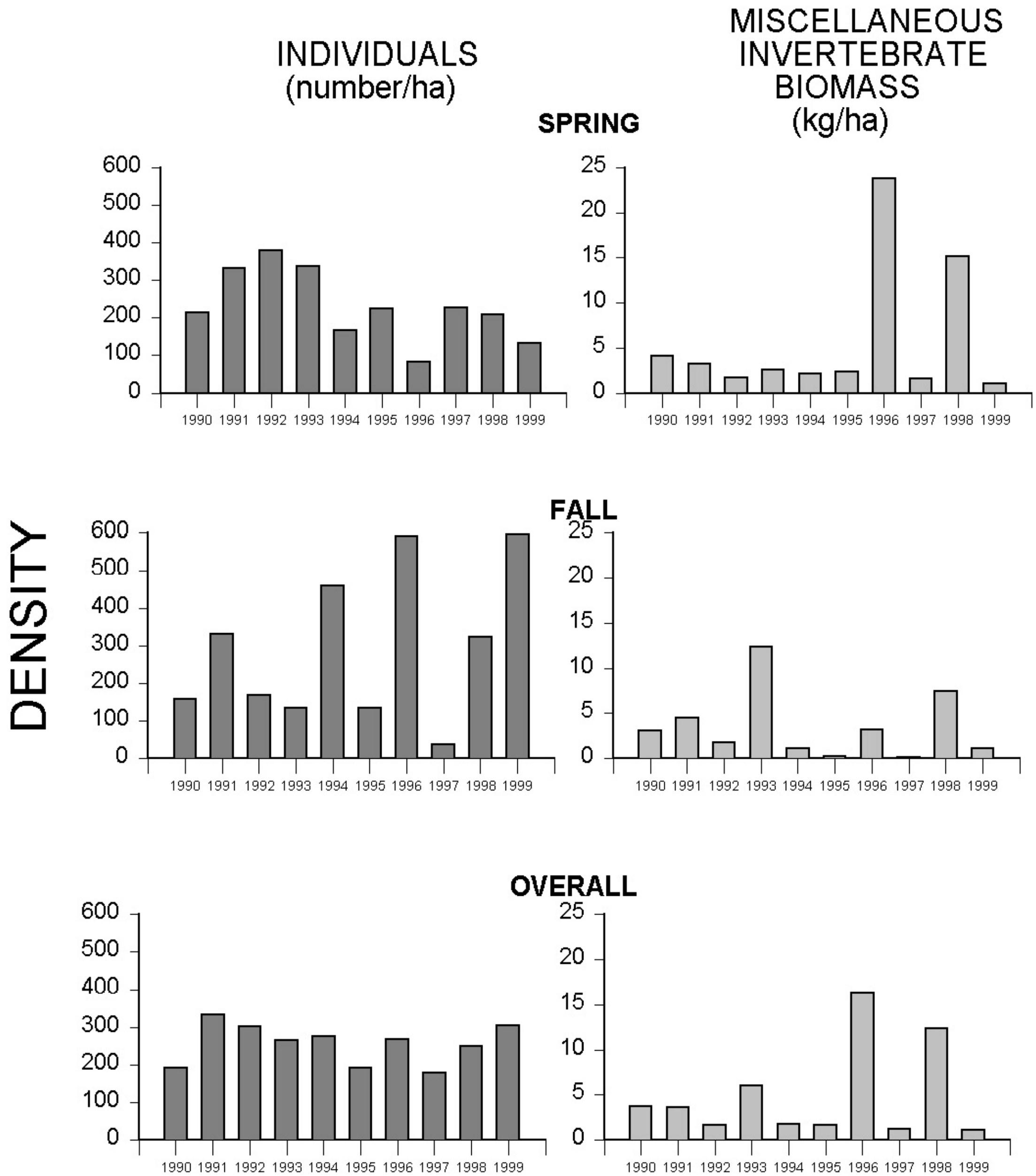



Figure 7 . Annual densities from outer strata.

## Distribution and Abundance of Priority Finfish Species

### *Archosargus probatocephalus*

Sheepshead range along the western Atlantic, Gulf of Mexico, and Central American coasts from Nova Scotia to Bahia de Sepetiba, Brazil (Randall, 1978). This species can be found in the brackish waters of estuaries as well as on reefs offshore.

The sheepshead, *Archosargus probatocephalus*, exhibited low abundance in SEAMAP-SA collections. Only 252 sheepshead (0.003 individuals/ha) weighing 646 kg (0.07 kg/ha) were taken in inner strata (Table 7). Catches of sheepshead peaked in 1992 and dropped to the lowest levels in 1998-1999 (Figure 8). Densities of abundance did not differ significantly among years ($X^2 = 13.4$, $p > 0.1$) Abundance was greatest in spring and fall and in Raleigh and Onslow Bays. Densities of abundance did not differ significantly among seasons ($X^2 = 0.7$, $p > 0.4$), but were significantly different among regions ($X^2 = 28.9$, $p < 0.0001$). Lengths ranged from 18-62 cm ($\bar{X} = 44.4$), with greatest mean length taken in spring (Figure 9) and in the northern SAB (Figure 10). Only 7 specimens were taken in outer strata.

### *Brevoortia smithi*

The yellowfin menhaden is found along the Atlantic coast of the United States from Beaufort, N. Carolina to Indian River, Florida and on the Gulf of Mexico coast from Florida Bay to Louisiana (Whitehead, 1978). *B. smithi* is a pelagic inshore species present in bays and estuaries.

Inner strata yielded a total of 436 yellowfin menhaden (0.06 individuals/ha) weighing 66 kg (0.01 kg/ha). Densities of abundance did not differ significantly among years ($X^2 = 3.5$, $p > 0.9$), although density of individuals was at the highest level in the history of the SEAMAP-SA project in 1991 (Figure 11), when 67% of all *Brevoortia smithi* from inner strata were taken. Although densities of abundance did not differ significantly among seasons ($X^2 = 2.0$, $p > 0.3$), abundance was significantly different among regions ($X^2 = 8.6$, $p < 0.05$). Density was greatest in spring, although spring collections were made only in waters off Georgia and Florida (Table 7). Yellowfin menhaden were most abundant in the southern portion of the SAB, with density of individuals decreasing northward. No *Brevoortia smithi* were collected in Raleigh or Long Bays, and only four individuals were taken north of Georgia waters. Outer strata produced 60 specimens, all in spring in the southern SAB ($\bar{X}$/ha = 0.06). Total lengths of *Brevoortia smithi* from inner strata ranged from 11 to 31 cm ($\bar{X} = 19.5$, n = 435), with a larger mean length in summer (Figure 12) and off South Carolina and Florida (Figure 13).

Table 7. Estimates of density (number of individuals/hectare) for priority finfish species among regions and seasons for inner strata 1990 -1999.

*Archosargus probatocephalus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.3 | 0 | 0.01 | 0.1 |
| Onslow Bay | 0.06 | 0.005 | 0.2 | 0.08 |
| Long Bay | 0.003 | 0.008 | 0.09 | 0.03 |
| South Carolina | 0.001 | 0 | 0.006 | 0.002 |
| Georgia | 0.006 | 0.002 | 0 | 0.01 |
| Florida | 0.005 | 0.008 | 0.04 | 0.02 |
| Season | 0.03 | 0.008 | 0.05 | 0.03 |

*Brevoortia smithi*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0 | 0 | 0 | 0 |
| Onslow Bay | 0 | 0.003 | 0.003 | 0.002 |
| Long Bay | 0 | 0 | 0 | 0 |
| South Carolina | 0 | 0.001 | 0.001 | 0.0008 |
| Georgia | 0.3 | 0.03 | 0.01 | 0.1 |
| Florida | 0.4 | 0.07 | 0.3 | 0.3 |
| Season | 0.1 | 0.02 | 0.05 | 0.06 |

*Brevoortia tyrannus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 1.0 | 0 | 0.3 | 0.5 |
| Onslow Bay | 1.2 | 0.05 | 0.08 | 0.4 |
| Long Bay | 2.0 | 0.09 | 0.1 | 0.7 |
| South Carolina | 3.5 | 0.06 | 0.5 | 1.4 |
| Georgia | 18.9 | 0.06 | 1.05 | 6.8 |
| Florida | 4.3 | 2.0 | 0.5 | 2.3 |
| Season | 6.1 | 0.3 | 0.5 | 2.3 |

*Centropristis striata*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.02 | 0.1 | 0.1 | 0.1 |
| Onslow Bay | 0.3 | 0.4 | 0.2 | 0.3 |
| Long Bay | 0.9 | 0.5 | 0.7 | 0.7 |
| South Carolina | 0.03 | 0.04 | 0.04 | 0.04 |
| Georgia | 0.05 | 0.03 | 0.02 | 0.03 |
| Florida | 0.003 | 0.02 | 0.02 | 0.02 |
| Season | 0.2 | 0.2 | 0.2 | 0.2 |

Table 7 (continued) Estimates of density (number of individuals/hectare)

*Chaetodipterus faber*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.07 | 0.07 | 11.6 | 3.9 |
| Onslow Bay | 0.03 | 6.5 | 2.8 | 3.1 |
| Long Bay | 0.05 | 2.4 | 0.2 | 0.9 |
| South Carolina | 0.02 | 0.6 | 0.4 | 0.3 |
| Georgia | 4.7 | 5.8 | 3.6 | 4.8 |
| Florida | 0.7 | 0.04 | 1.9 | 0.9 |
| Season | 1.1 | 2.7 | 2.1 | 1.9 |

*Cynoscion nebulosus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0 | 0 | 0 | 0 |
| Onslow Bay | 0 | 0 | 0.02 | 0.005 |
| Long Bay | 0 | 0 | 0 | 0 |
| South Carolina | 0 | 0.001 | 0 | 0.0004 |
| Georgia | 0.002 | 0.002 | 0 | 0.001 |
| Florida | 0 | 0 | 0 | 0 |
| Season | 0.0003 | 0.0007 | 0.002 | 0.001 |

*Cynoscion regalis*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 111.3 | 50.5 | 28.5 | 64.7 |
| Onslow Bay | 16.3 | 5.3 | 2.1 | 8.0 |
| Long Bay | 14.9 | 2.7 | 1.5 | 6.4 |
| South Carolina | 2.1 | 3.7 | 1.8 | 2.5 |
| Georgia | 1.4 | 1.0 | 1.6 | 1.3 |
| Florida | 2.2 | 0.8 | 3.6 | 2.2 |
| Season | 12.2 | 5.1 | 3.3 | 6.9 |

*Leiostomus xanthurus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 168.1 | 64.2 | 135.2 | 123.9 |
| Onslow Bay | 157.1 | 73.6 | 49.1 | 94.2 |
| Long Bay | 243.9 | 41.9 | 43.1 | 110.5 |
| South Carolina | 106.7 | 45.5 | 6.1 | 53.2 |
| Georgia | 23.7 | 10.0 | 6.9 | 13.7 |
| Florida | 127.8 | 211.9 | 6.2 | 119.4 |
| Season | 129.9 | 64.1 | 26.0 | 73.9 |

Table 7 (continued) Estimates of density (number of individuals/hectare)

*Menticirrhus americanus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 21.8 | 7.5 | 23.0 | 17.6 |
| Onslow Bay | 4.9 | 1.6 | 4.3 | 3.6 |
| Long Bay | 3.3 | 3.5 | 3.0 | 3.3 |
| South Carolina | 8.9 | 4.5 | 9.1 | 7.5 |
| Georgia | 7.1 | 7.5 | 10.8 | 8.5 |
| Florida | 9.6 | 21.0 | 22.4 | 17.6 |
| Season | 7.6 | 6.9 | 10.0 | 8.2 |

*Menticirrhus littoralis*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.006 | 0.01 | 0.2 | 0.07 |
| Onslow Bay | 0.03 | 0.02 | 0.2 | 0.07 |
| Long Bay | 0.03 | 0.02 | 0.06 | 0.04 |
| South Carolina | 0.05 | 0.008 | 0.1 | 0.06 |
| Georgia | 0.06 | 0.01 | 0.1 | 0.06 |
| Florida | 0.7 | 0.5 | 1.9 | 1.03 |
| Season | 0.1 | 0.08 | 0.3 | 0.2 |

*Menticirrhus saxatilis*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 2.3 | 0.1 | 4.0 | 2.1 |
| Onslow Bay | 0.2 | 0.05 | 0.2 | 0.1 |
| Long Bay | 0.03 | 0.04 | 0.02 | 0.03 |
| South Carolina | 0 | 0.004 | 0.02 | 0.007 |
| Georgia | 0 | 0.003 | 0.003 | 0.002 |
| Florida | 0.003 | 0.06 | 0.005 | 0.02 |
| Season | 0.2 | 0.03 | 0.2 | 0.1 |

*Micropogonias undulatus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 282.9 | 115.3 | 283.9 | 229.3 |
| Onslow Bay | 112.4 | 97.4 | 81.4 | 97.3 |
| Long Bay | 129.5 | 95.5 | 40.0 | 88.4 |
| South Carolina | 9.8 | 48.6 | 17.2 | 25.1 |
| Georgia | 20.7 | 22.8 | 18.0 | 20.5 |
| Florida | 68.9 | 166.6 | 6.2 | 81.6 |
| Season | 71.8 | 78.1 | 42.4 | 64.2 |

Table 7 (continued) Estimates of density (number of individuals/hectare)

*Mycteroperca microlepis*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0 | 0 | 0.01 | 0.004 |
| Onslow Bay | 0 | 0 | 0.003 | 0.0009 |
| Long Bay | 0 | 0 | 0 | 0 |
| South Carolina | 0 | 0 | 0 | 0 |
| Georgia | 0 | 0 | 0 | 0 |
| Florida | 0 | 0 | 0 | 0 |
| Season | 0 | 0 | 0.001 | 0.0003 |

*Paralichthys albigutta*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.006 | 0.02 | 0.1 | 0.04 |
| Onslow Bay | 0.01 | 0.06 | 0.05 | 0.04 |
| Long Bay | 0.003 | 0.02 | 0.01 | 0.01 |
| South Carolina | 0.004 | 0.005 | 0.007 | 0.005 |
| Georgia | 0.003 | 0.003 | 0.001 | 0.003 |
| Florida | 0.04 | 0.1 | 0.02 | 0.06 |
| Season | 0.009 | 0.03 | 0.02 | 0.02 |

*Paralichthys dentatus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.9 | 1.5 | 3.9 | 2.1 |
| Onslow Bay | 0.6 | 0.8 | 1.4 | 0.9 |
| Long Bay | 0.5 | 0.5 | 0.3 | 0.4 |
| South Carolina | 0.3 | 0.5 | 0.3 | 0.3 |
| Georgia | 0.06 | 0.2 | 0.1 | 0.1 |
| Florida | 0.07 | 0.1 | 0.07 | 0.09 |
| Season | 0.3 | 0.5 | 0.6 | 0.4 |

*Paralichthys lethostigma*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.02 | 0.03 | 0.06 | 0.03 |
| Onslow Bay | 0.03 | 0.04 | 0.08 | 0.05 |
| Long Bay | 0.07 | 0.03 | 0.07 | 0.06 |
| South Carolina | 0.05 | 0.04 | 0.2 | 0.09 |
| Georgia | 0.03 | 0.05 | 0.09 | 0.05 |
| Florida | 0.04 | 0.05 | 0.03 | 0.04 |
| Season | 0.05 | 0.04 | 0.1 | 0.06 |

Table 7 (continued) Estimates of density (number of individuals/hectare)

*Peprilus alepidotus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 3.9 | 1.2 | 46.8 | 17.1 |
| Onslow Bay | 4.1 | 3.7 | 14.3 | 7.3 |
| Long Bay | 1.4 | 4.4 | 9.2 | 5.0 |
| South Carolina | 0.5 | 2.4 | 5.9 | 2.9 |
| Georgia | 2.7 | 1.6 | 5.1 | 3.2 |
| Florida | 1.8 | 1.8 | 8.6 | 4.0 |
| Season | 2.0 | 2.7 | 9.9 | 4.8 |

*Peprilus triacanthus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 49.7 | 4.6 | 35.9 | 30.7 |
| Onslow Bay | 7.7 | 1.0 | 1.7 | 3.5 |
| Long Bay | 11.7 | 1.4 | 1.5 | 4.9 |
| South Carolina | 7.9 | 2.4 | 0.3 | 3.5 |
| Georgia | 3.6 | 0.1 | 1.5 | 1.8 |
| Florida | 2.8 | 1.3 | 1.2 | 1.7 |
| Season | 9.3 | 1.5 | 2.9 | 4.6 |

*Pogonias cromis*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0 | 0 | 0.03 | 0.009 |
| Onslow Bay | 0.003 | 0 | 0.01 | 0.004 |
| Long Bay | 0.002 | 0 | 0.002 | 0.001 |
| South Carolina | 0 | 0 | 0.01 | 0.003 |
| Georgia | 0 | 0 | 0.04 | 0.01 |
| Florida | 0 | 0 | 0.04 | 0.01 |
| Season | 0.0007 | 0 | 0.02 | 0.007 |

*Pomatomus saltatrix*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 7.6 | 0.2 | 6.2 | 4.8 |
| Onslow Bay | 5.8 | 1.0 | 1.3 | 2.7 |
| Long Bay | 6.4 | 0.5 | 0.8 | 2.6 |
| South Carolina | 1.8 | 0.2 | 0.6 | 0.9 |
| Georgia | 0.5 | 0.05 | 0.6 | 0.4 |
| Florida | 0.2 | 0.4 | 0.4 | 0.3 |
| Season | 3.1 | 0.4 | 1.0 | 1.5 |

Table 7 (continued) Estimates of density (number of individuals/hectare)

*Sciaenops ocellatus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0 | 0 | 0 | 0 |
| Onslow Bay | 0 | 0 | 0 | 0 |
| Long Bay | 0.002 | 0 | 0 | 0.0005 |
| South Carolina | 0.001 | 0 | 0.002 | 0.001 |
| Georgia | 0 | 0 | 0 | 0 |
| Florida | 0 | 0 | 0 | 0 |
| Season | 0.0007 | 0 | 0.0007 | 0.0004 |

*Scomberomorus cavalla*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.02 | 0.04 | 1.2 | 0.4 |
| Onslow Bay | 0 | 0.2 | 1.8 | 0.7 |
| Long Bay | 0.1 | 0.2 | 1.4 | 0.5 |
| South Carolina | 0.1 | 0.1 | 1.5 | 0.6 |
| Georgia | 0.4 | 0.1 | 1.0 | 0.5 |
| Florida | 0.6 | 2.1 | 3.9 | 2.2 |
| Season | 0.2 | 0.4 | 1.7 | 0.8 |

*Scomberomorus maculatus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.2 | 0.5 | 1.2 | 0.6 |
| Onslow Bay | 0.3 | 2.1 | 1.9 | 1.4 |
| Long Bay | 0.8 | 2.0 | 1.1 | 1.3 |
| South Carolina | 1.5 | 1.5 | 0.6 | 1.2 |
| Georgia | 2.6 | 1.7 | 1.3 | 1.9 |
| Florida | 1.6 | 3.0 | 2.4 | 2.3 |
| Season | 1.4 | 1.9 | 1.3 | 1.5 |

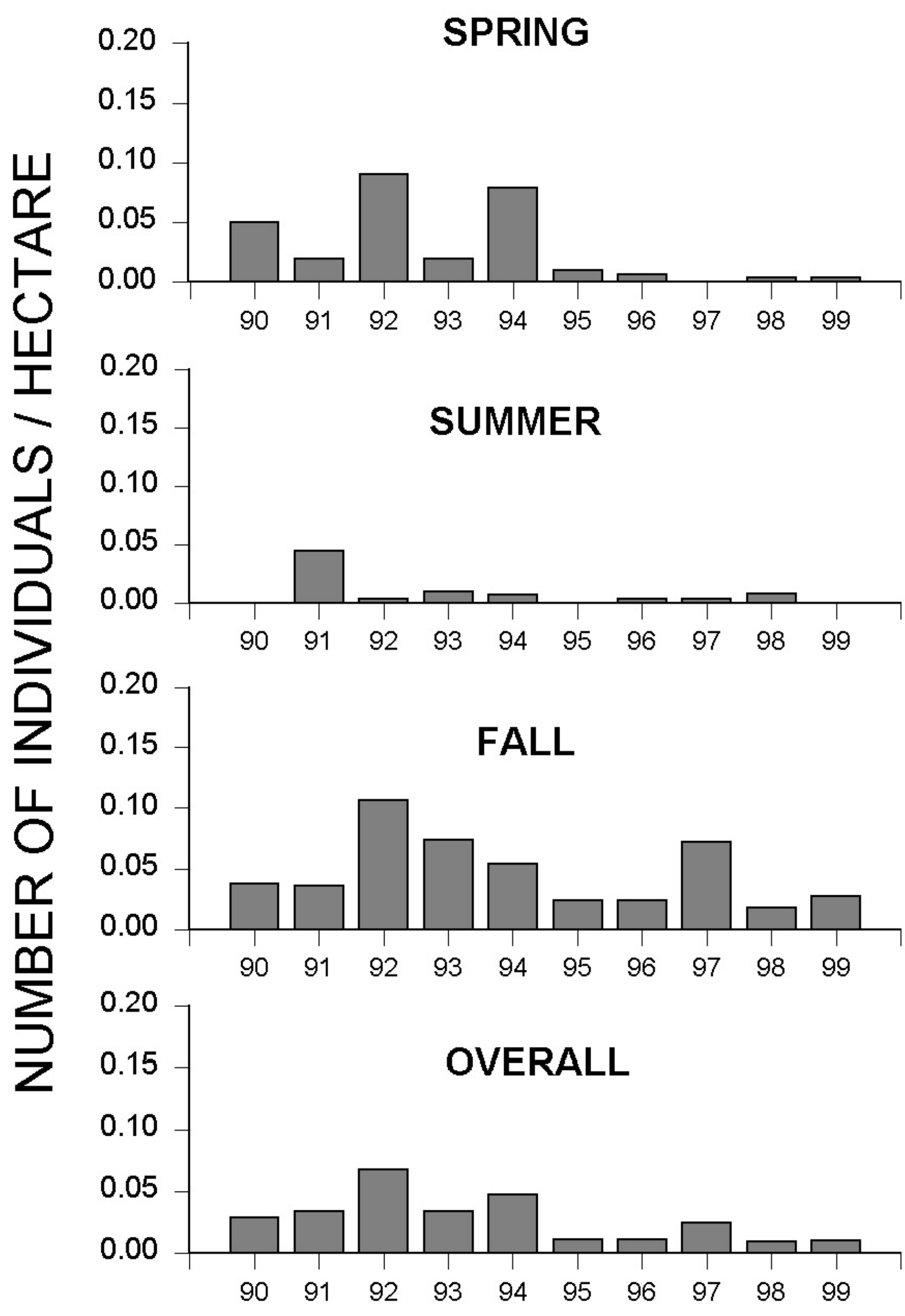



Figure 8. Annual densities of *Archosargus probatocephalus* from inner strata

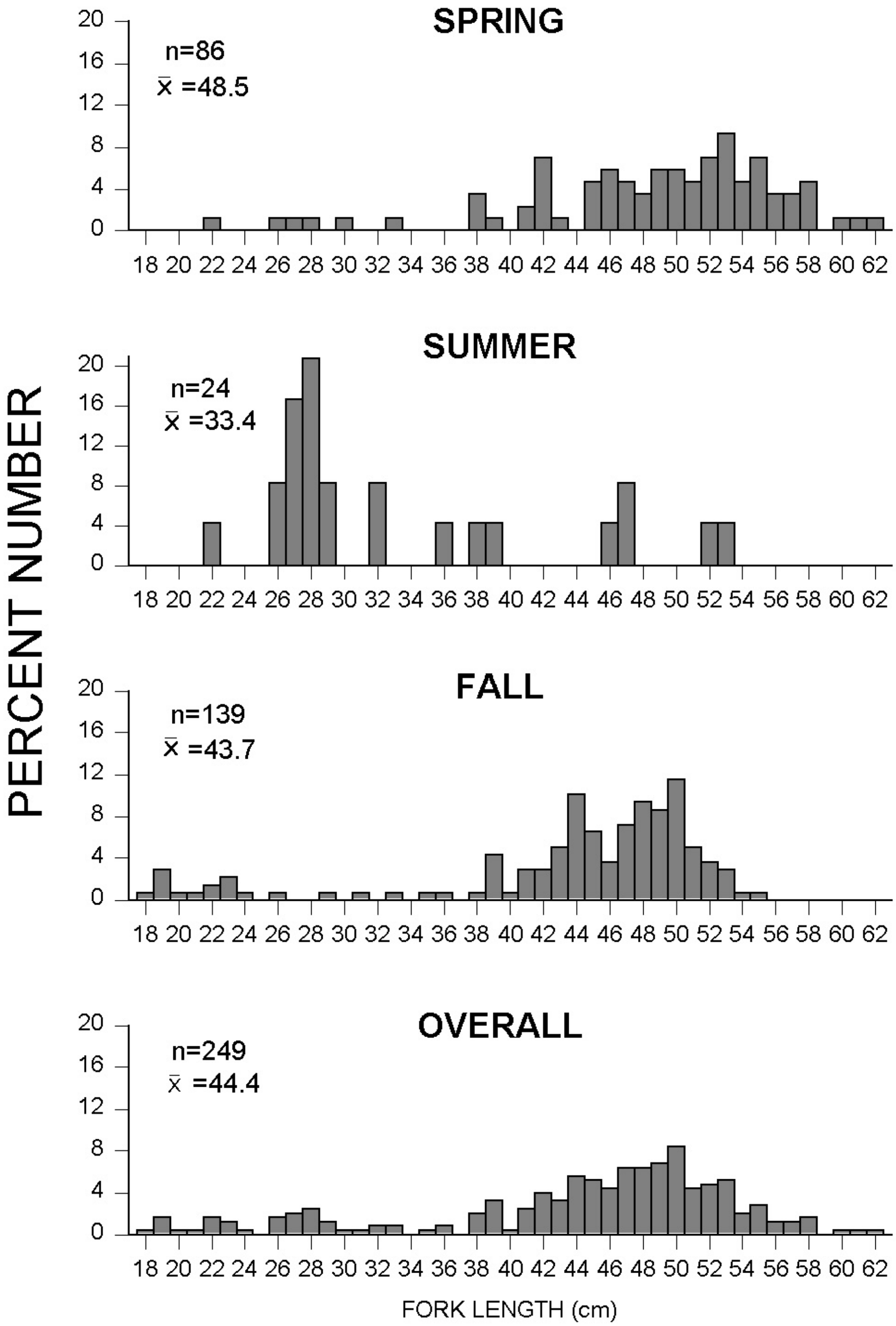



Figure 9. Seasonal length-frequencies of *Archosargus probatocephalus* from inner strata 1990-1999.

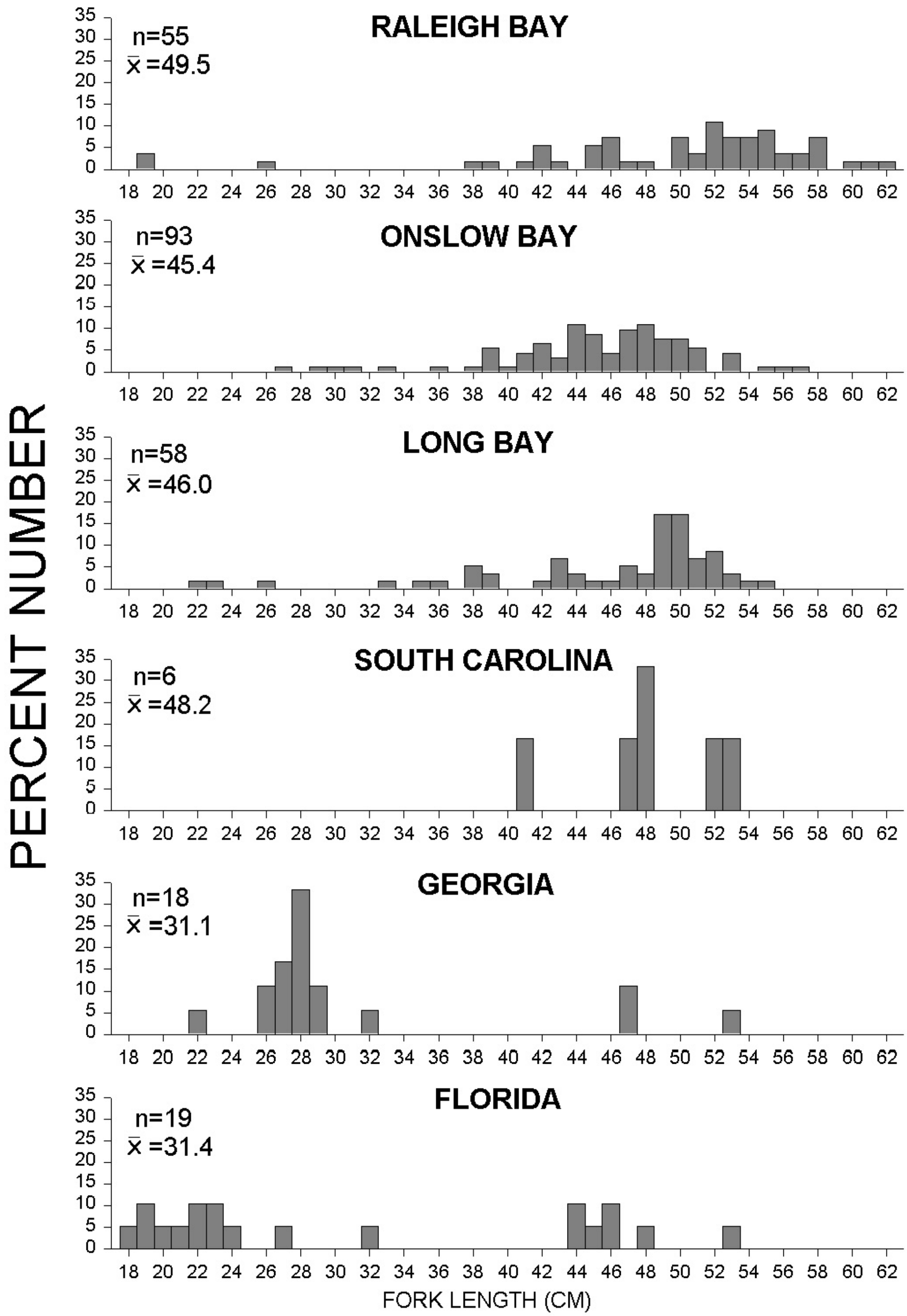



Figure 10. Regional length-frequencies of *Archosargus probatocephalus* in inner strata 1990-1999.

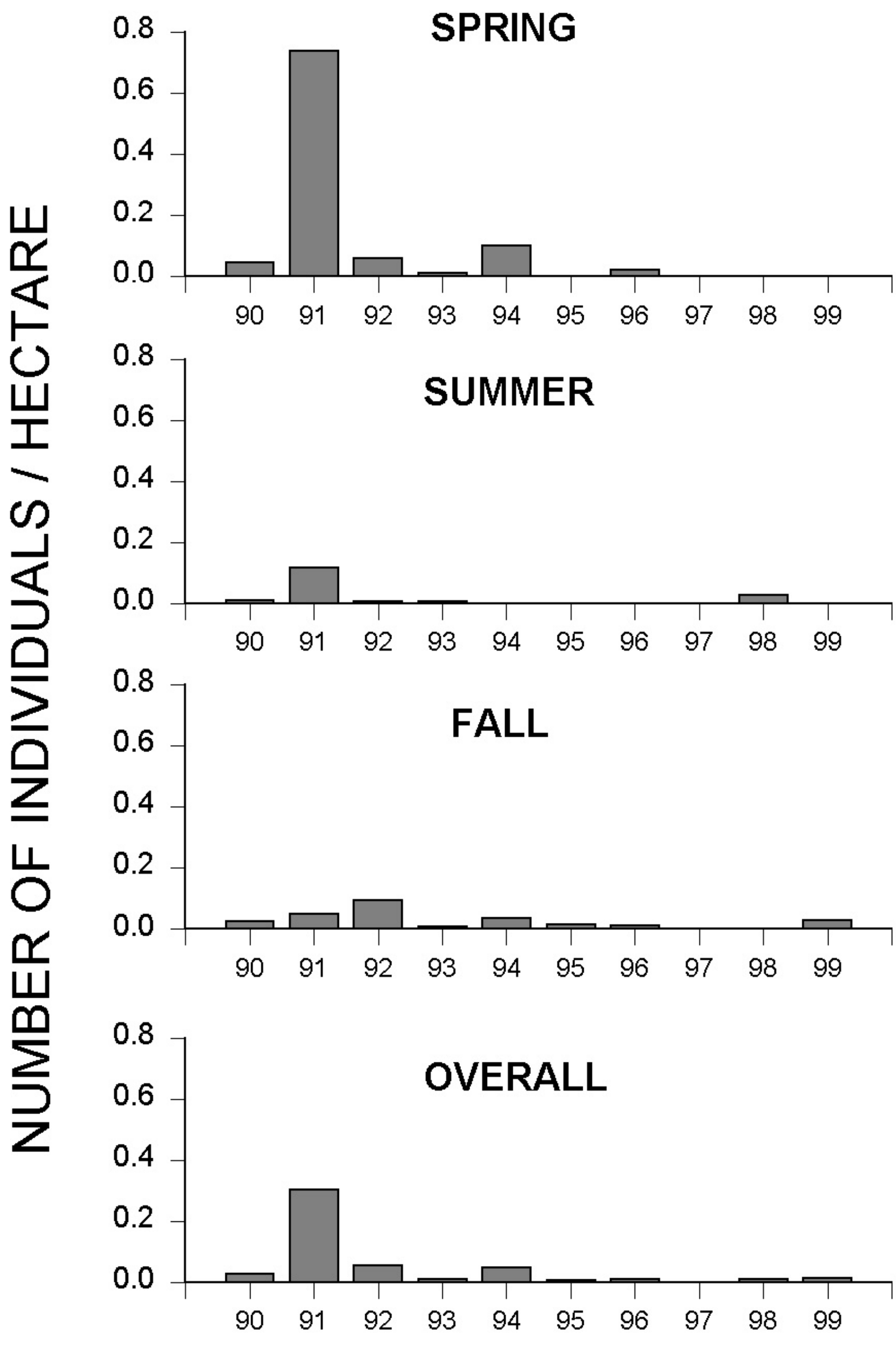



Figure 11. Annual densities of *Brevoortia smithi* from inner strata

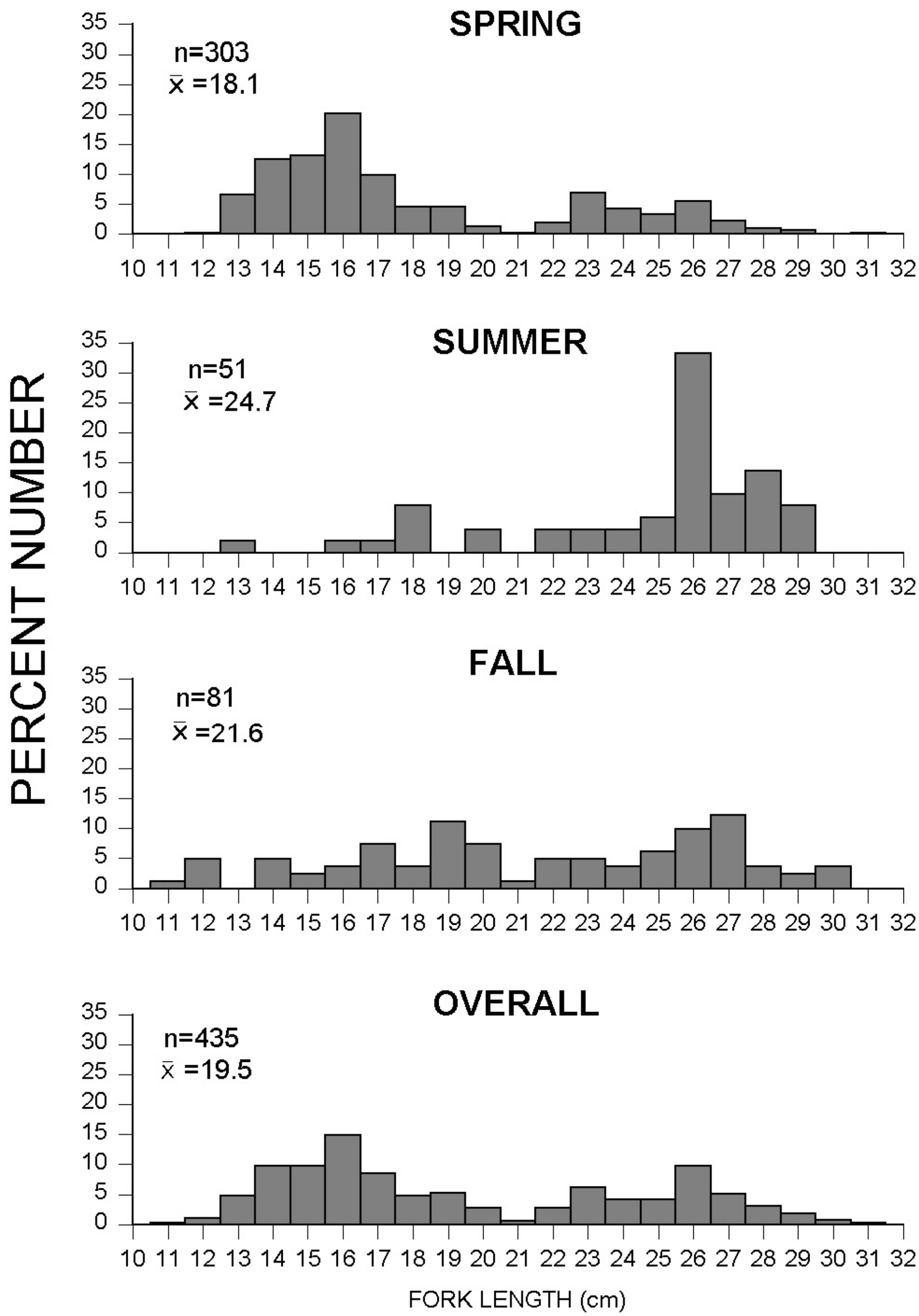



Figure 12. Seasonal length-frequencies of *Brevoortia smithi* from inner strata 1990-1999.

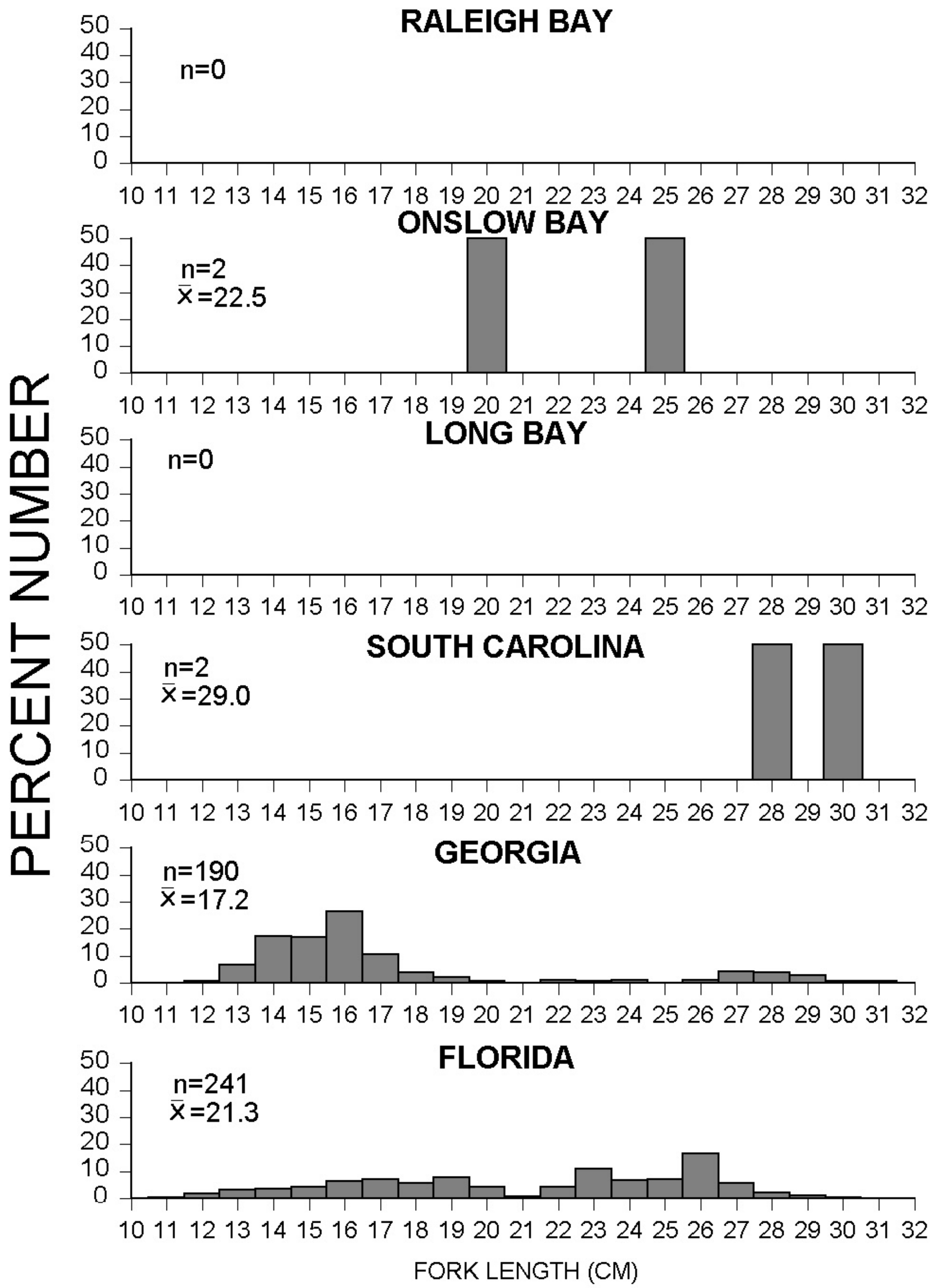



Figure 13. Regional length-frequencies of *Brevoortia smithi* in inner strata 1990-1999.

***Brevoortia tyrannus***

The Atlantic menhaden occurs from Nova Scotia to Jupiter Inlet, Florida (Whitehead, 1978). *Brevoortia tyrannus* occurs in large, dense schools which are targeted by the purse-seine fishery off North Carolina (Smith, 1999).

Inner strata yielded a total of 16,634 Atlantic menhaden (2.3 individuals/ha) weighing 444 kg (0.07 kg/ha). Density of individuals was at the highest level in the history of the survey in 1990 (Figure 14). Nevertheless, densities of abundance did not differ significantly among years ($X^2 = 16.7$, $p > 0.05$). Densities of abundance were significantly among seasons ($X^2 = 7.7$, $p < 0.05$) and regions ($X^2 = 15.4$, $p < 0.01$), however. Density was greatest in spring (Table 7); approximately 90% of all Atlantic menhaden taken in inner strata were collected during spring cruises. Atlantic menhaden were most abundant in waters off Georgia. Outer strata produced 194 specimens, all of which were collected in spring in the southern SAB ($\bar{X}$/ha = 0.18), with the exception of a single individual taken in fall.

Total lengths of *Brevoortia tyrannus* ranged from 9 to 32 cm ($\bar{X} = 13.8$, n = 16,631). Length was significantly different among seasons ($X^2 = 132$, $p < 0.0001$). Mean length increased from spring to fall, indicating the recruitment of YOY individuals and subsequent juvenile growth (Figure 15). Mean length also varied significantly among regions ($X^2 = 81$, $p < 0.0001$), with larger fish occurring in Raleigh Bay (Figure 16), where the fewest menhaden were collected. The length-frequency distributions of Atlantic menhaden in the SAB were numerically dominated by individuals taken in spring when few large specimens were taken. Approximately 70% of the Atlantic menhaden in inner strata were caught off Georgia. Mean length of Atlantic menhaden was greatest in collections from Raleigh Bay and smallest in Long Bay.

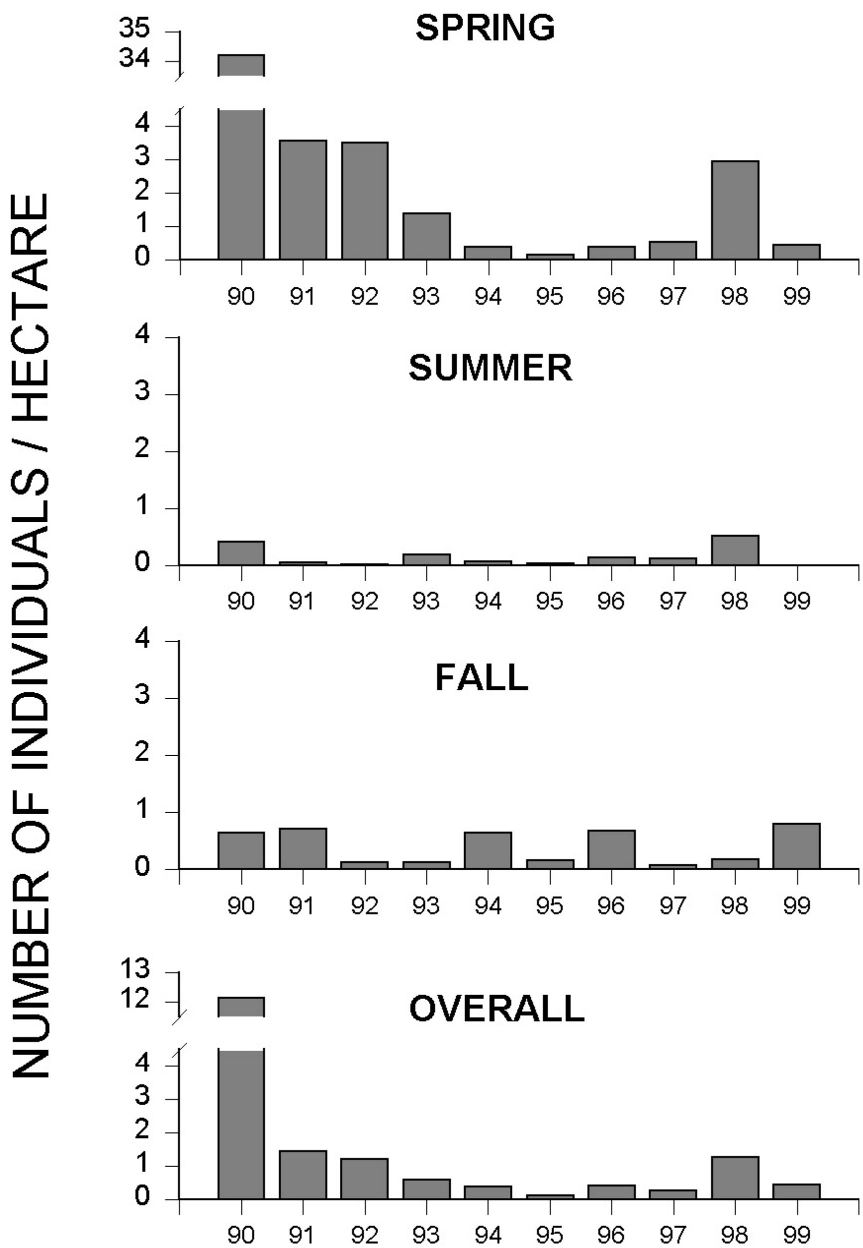



Figure 14. Annual densities of *Brevoortia tyrannus* from inner strata

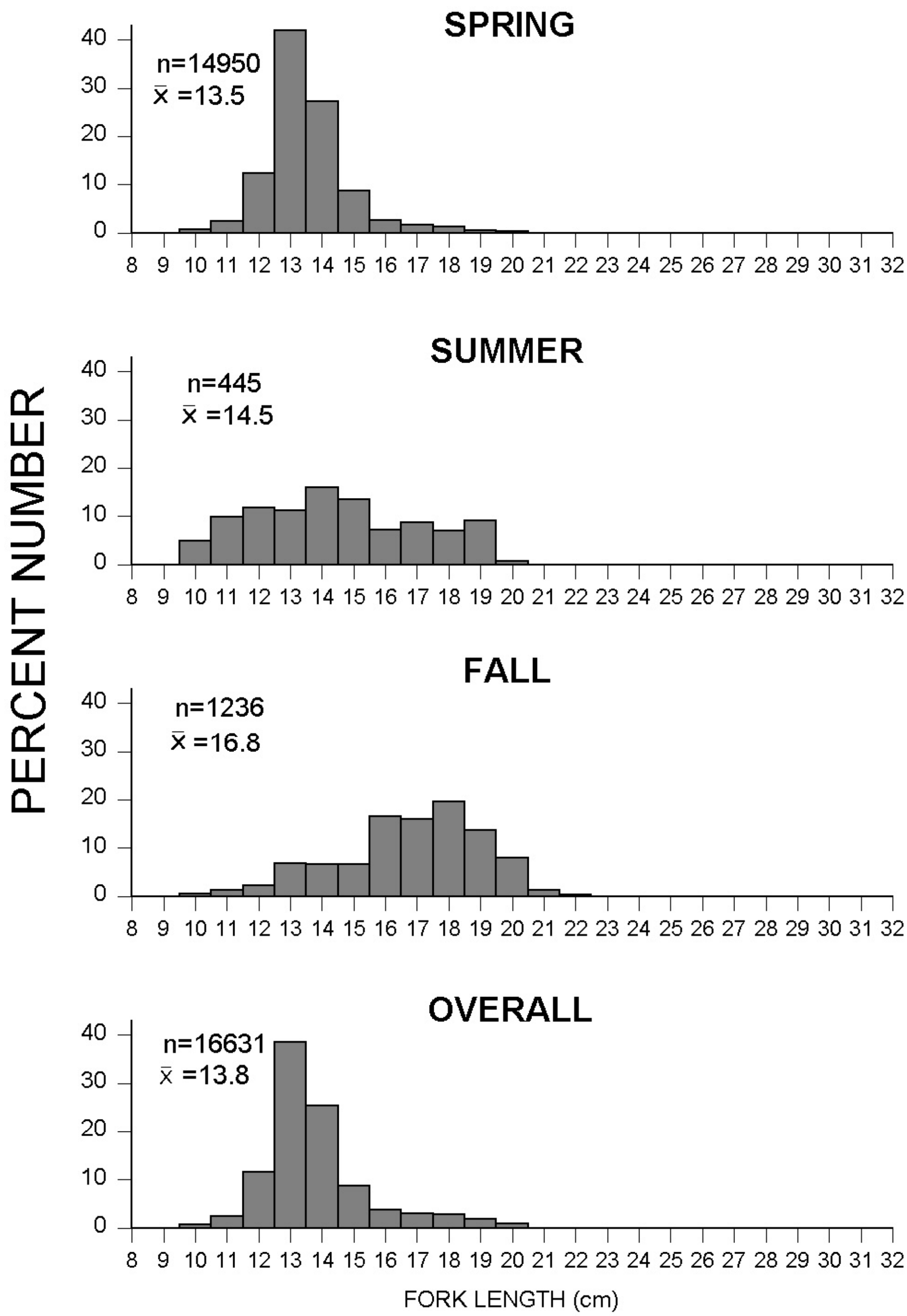



Figure 15. Seasonal length-frequencies of *Brevoortia tyrannus* from inner strata 1990-1999.

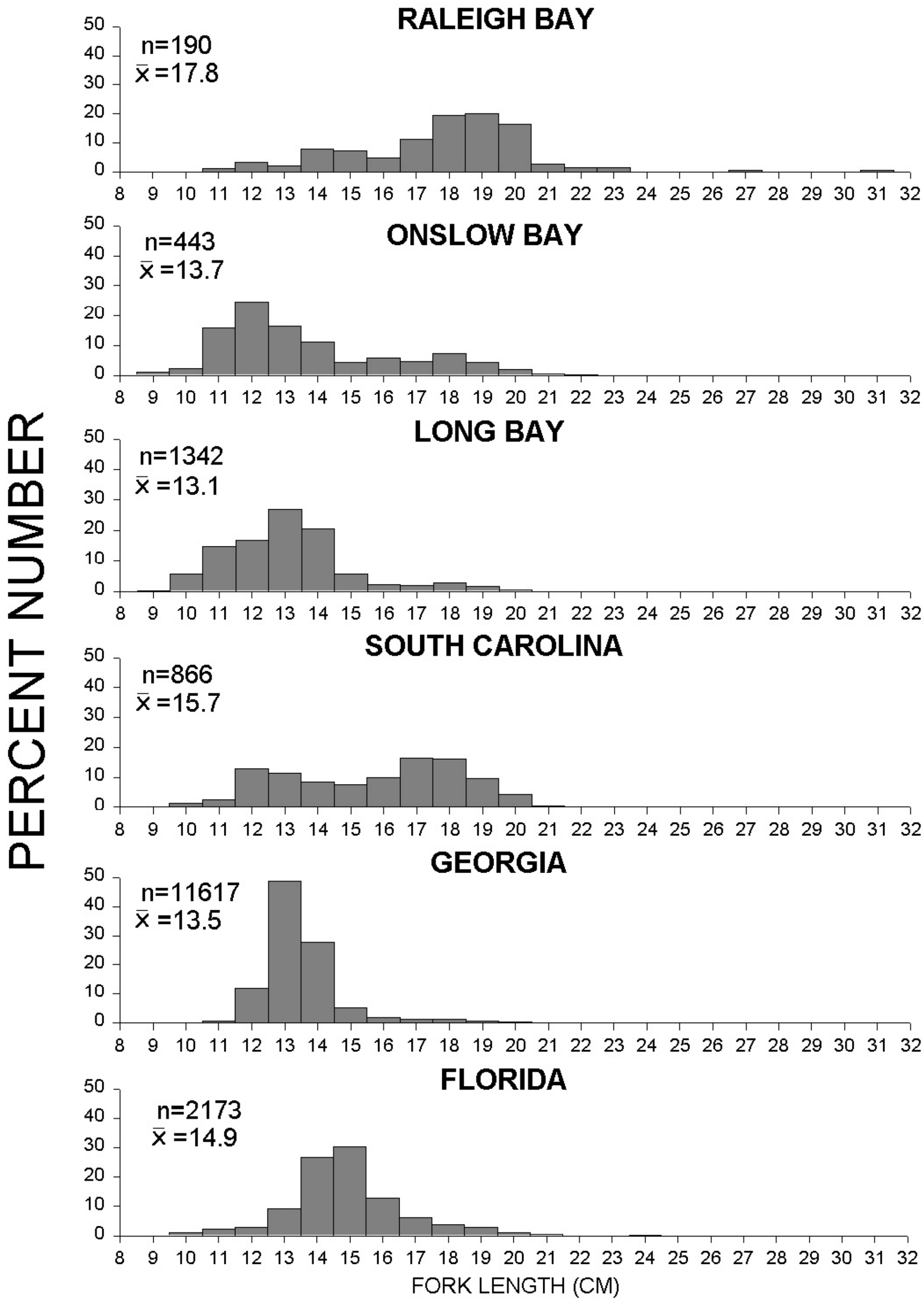



Figure 16. Regional length-frequencies of *Brevoortia tyrannus* in inner strata 1990-1999.

## *Centropristis striata*

Black sea bass occur on the western Atlantic coast from Massachusetts to Florida and in the Gulf of Mexico along the Florida coast from Placida to Pensacola (Smith, 1978). This species occurs around rocky and hard bottom, jetties, ledges, and pilings in shallow water (Robins and Ray, 1986). It is dispersed over a wide area on the continental shelf.

Inner strata yielded a total of 1484 black sea bass (0.2 individuals/ha) weighing 108 kg (0.01 kg/ha). Density of individuals varied significantly among years ($X^2 = 27.2$, $p < 0.001$), with density at the highest level in the history of the survey in 1994, followed by a secondary peak in 1998 (Figure 17). Density did not vary a great deal seasonally overall (Table 7) and was not found to differ significantly among seasons ($X^2 = 1.6$, $p > 0.70$). Density was significantly different among regions ($X^2 = 46.4$, $p < 0.0001$). Black sea bass were most abundant in Onslow and Long Bays, where approximately 89% of all individuals from inner strata were taken. Outer strata produced 296 specimens (spring: n = 174, $\bar{X}$/ha = 0.16; fall: n = 122, $\bar{X}$/ha = 0.2).

Total lengths of *Centropristis striata* ranged from 5 to 35 cm (n = 1482). Length was significantly different among seasons ($X^2 = 30$, $p < 0.0001$). Mean length decreased from summer to fall, indicating the recruitment of YOY individuals (Figure 18). Length also varied significantly among regions ($X^2 = 13$, $p < 0.05$), with larger fish occurring in Onslow and Long Bays and off South Carolina (Figure 19). The majority of fish from Onslow Bay were taken in summer collections, whereas fall specimens were numerically dominant in the Long Bay length-frequency distributions.

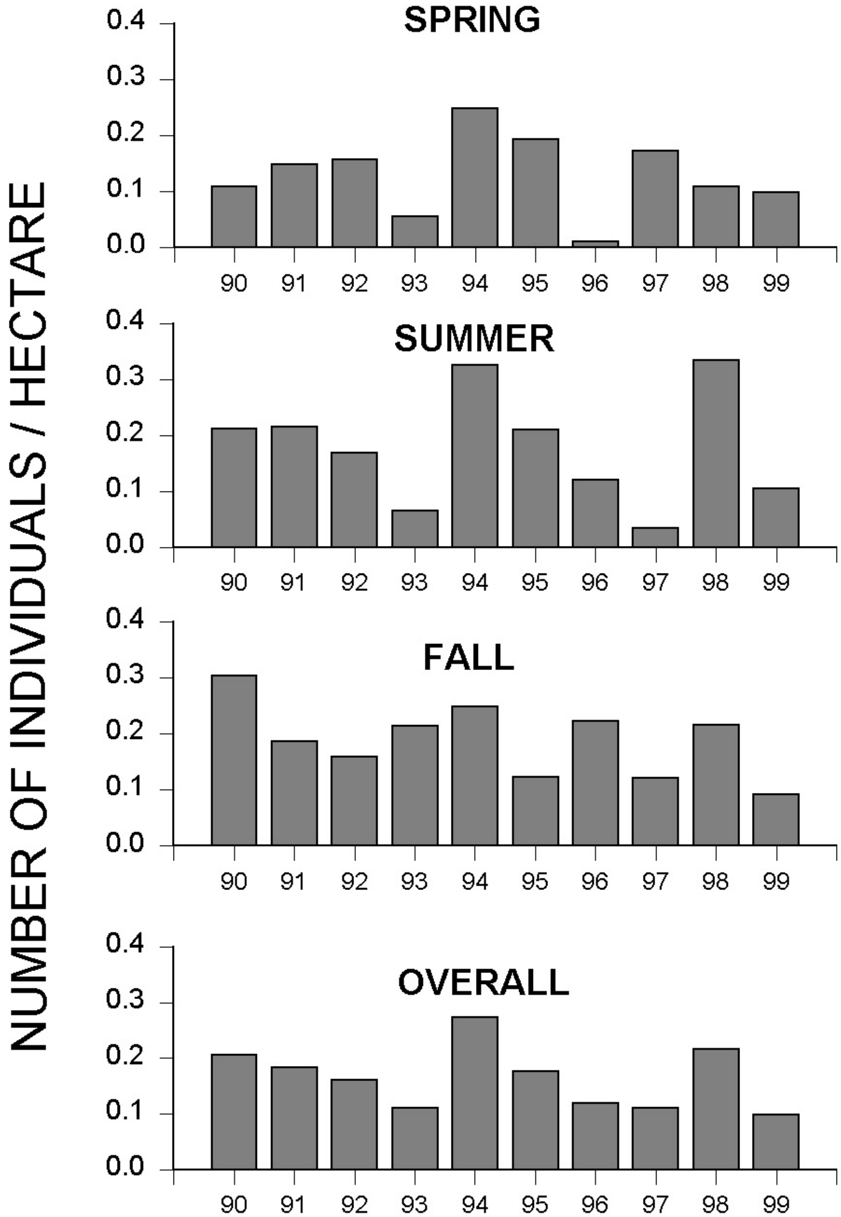



Figure 17. Annual densities of *Centropristis striata* from inner strata

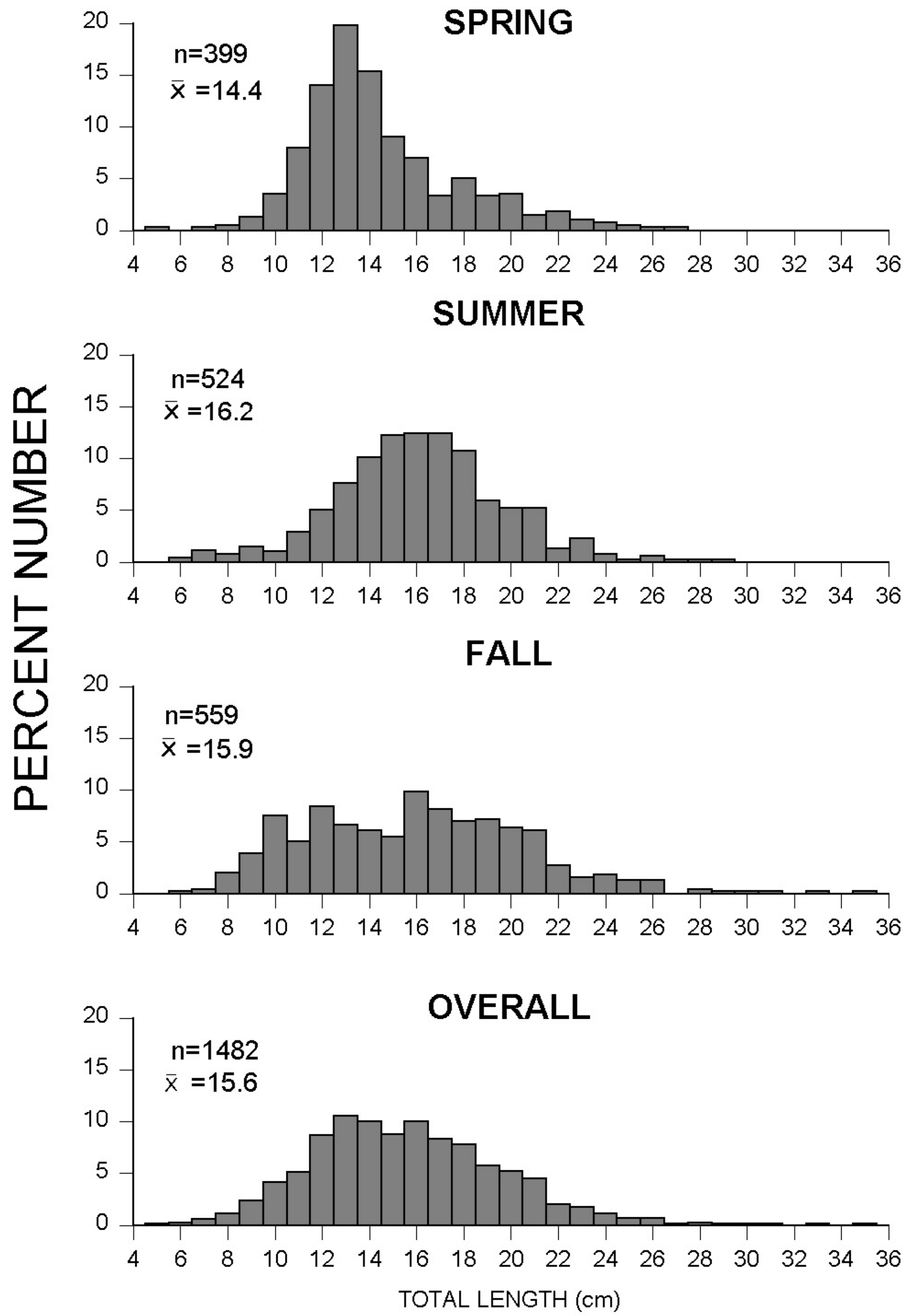



Figure 18. Seasonal length-frequencies of *Centropristis striata* from inner strata 1990-1999.

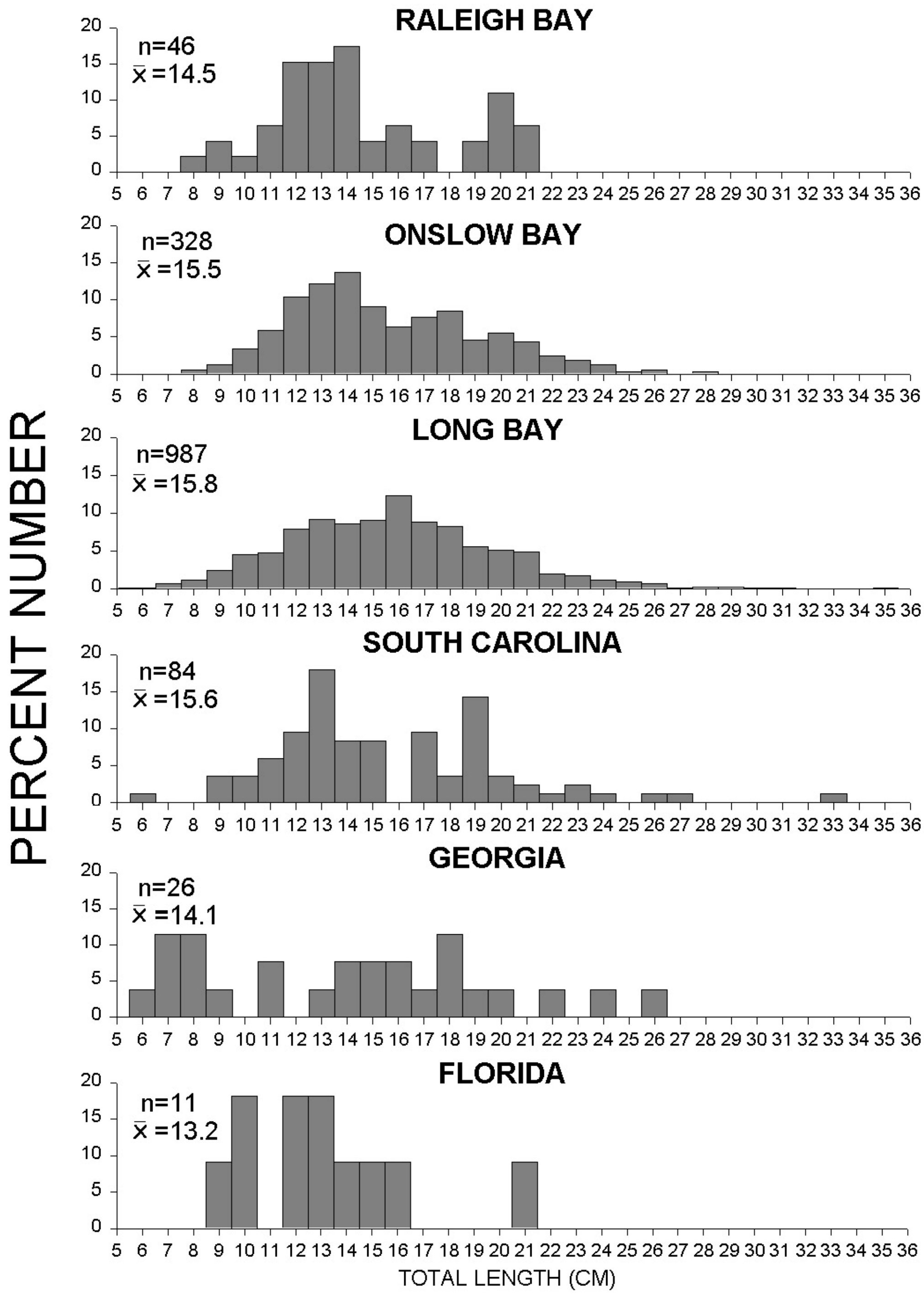



Figure 19. Regional length-frequencies of *Centropristis striata* in inner strata 1990-1999.

### *Chaetodipterus faber*

The Atlantic spadefish inhabits coastal waters from Chesapeake Bay to Brazil, throughout the Gulf of Mexico, and has been introduced into Bermuda (Burgess 1978). Adults tend to congregate in schools around wrecks, pilings, rocky or reef areas. Spadefish are a common fish in South Carolina, particularly from early spring to late fall (Hayse, 1987).

Inner strata yielded a total of 16,968 Atlantic spadefish (2.0 individuals/ha) weighing 1541 kg (0.2 kg/ha). Density of individuals peaked in 1991, with a general decline in a abundance in subsequent years (Figure 20). Density was found to vary significantly among years ($X^2 = 48.5$, $p < 0.0001$), seasons ($X^2 = 27.1$, $p < 0.0001$), and regions ($X^2 = 48.3$, $p < 0.0001$). Density was greatest in summer (Table 7). Atlantic spadefish were most abundant in waters off Georgia and the northern portion of the SAB (Raleigh and Onslow Bays). Outer strata produced 1600 specimens (spring: n = 978, $\overline{X}$/ha = 0.91; fall: n = 622, $\overline{X}$/ha = 1.05).

Total lengths of *Chaetodipterus faber* ranged from 3 to 42 cm ($\overline{X}$ = 12.1, n = 16,958). Length was significantly different among seasons ($X^2 = 774$, $p < 0.0001$). Mean length decreased from summer to fall, indicating the recruitment of YOY individuals (Figure 21). Mean length also varied significantly among regions ($X^2 = 55$, $p < 0.0001$), with larger fish occurring in Onslow and Long Bays (Figure 22). The length-frequency distribution of Atlantic spadefish in Raleigh Bay comprised primarily fall specimens (99%), whereas the distributions from Onslow and Long Bays represented fish taken primarily from summer trawls. Less than 5% of all Atlantic spadefish taken in inner strata were caught off South Carolina. In contrast, approximately 51% were taken from waters off Georgia. In the three southernmost regions, the majority of larger specimens were taken in summer and smaller individuals in fall.

### *Cynoscion nebulosus*

The spotted seatrout inhabits the western Atlantic coast from New York to South Florida and the Gulf of Mexico coast from South Florida to Laguna Madre, Mexico (Chao, 1978). Found over sand bottoms in shallow coastal waters and river estuaries as well as being found near seagrass beds and salt marshes in these habitats.

The spotted seatrout, *Cynoscion nebulosus*, proved to be a rare species in SEAMAP-SA collections. In the ten-year period from 1990 -1999 only nine specimens (0.001 individuals/ha) were collected, all in inner strata. Spotted seatrout were collected only in Onslow Bay and in waters off South Carolina and Georgia (Table 7). Lengths of *Cynoscion nebulosus* ranged from 25 to 30 cm ($\overline{X}$ = 26.8).

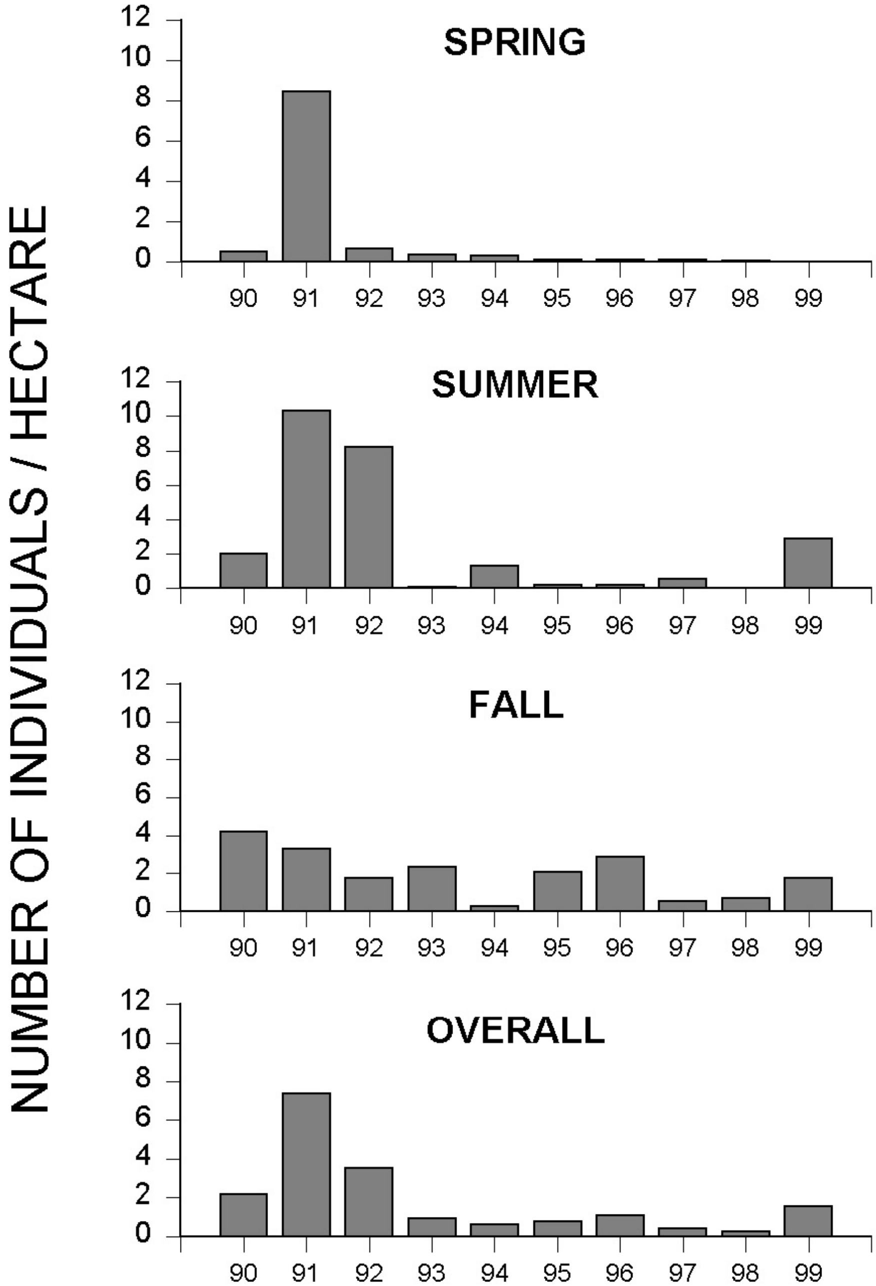



Figure 20. Annual densities of *Chaetodipterus faber* from inner strata

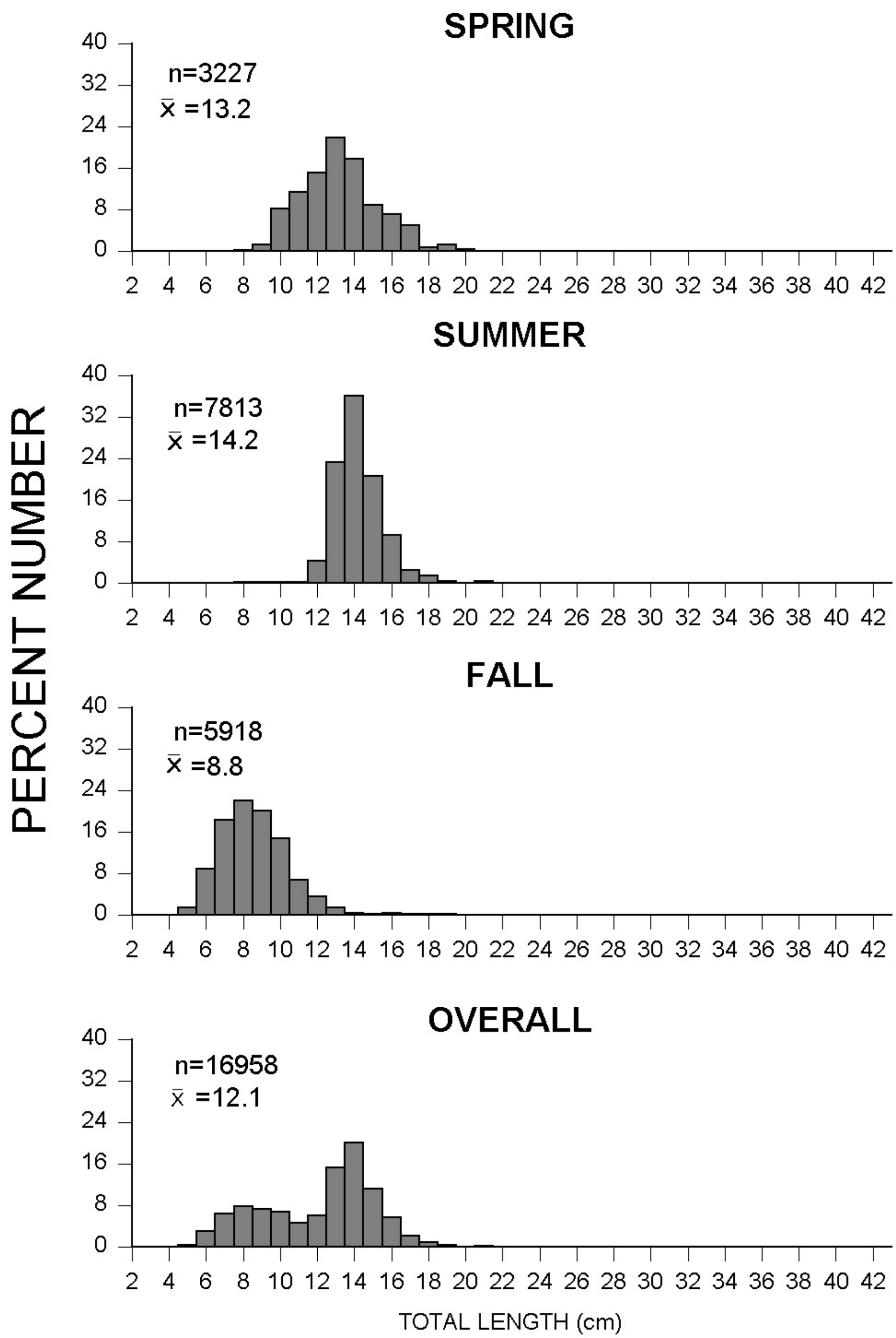



Figure 21. Seasonal length-frequencies of *Chaetodipterus faber* from inner strata 1990-1999.

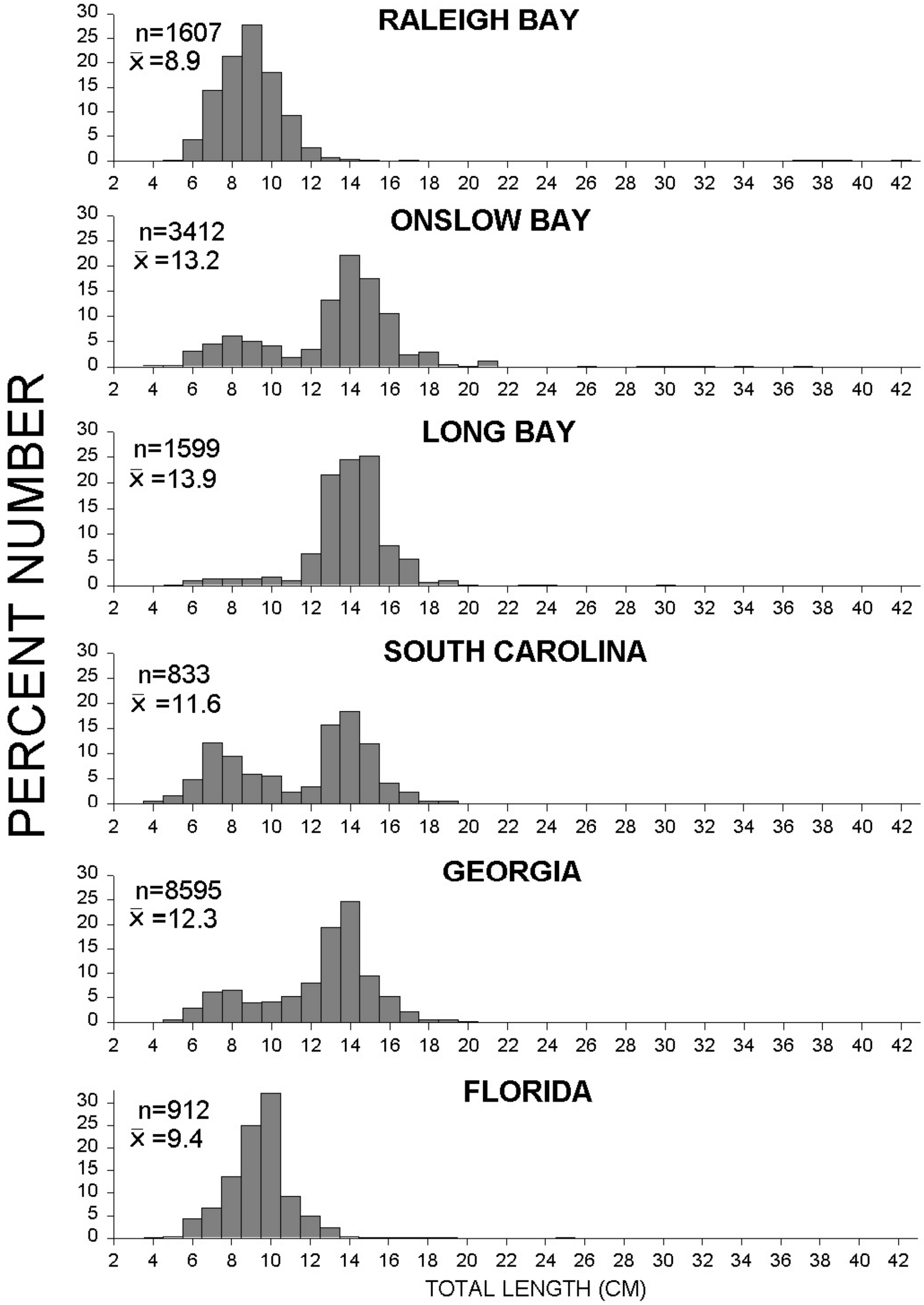



Figure 22. Regional length-frequencies of *Chaetodipterus faber* in inner strata 1990-1999.

***Cynoscion regalis***

Weakfish occur along the Atlantic coast of the United States from Nova Scotia to southern Florida and occasionally to the Gulf coast of Florida (Chao, 1978). Weakfish in the SAB are reported to move south from waters off North Carolina to Florida during fall migrations (Mercer, 1985). The weakfish is an important commercial and recreational species, primarily caught by hook-and-line, gill-nets, and bottom trawls (Bigelow and Schroeder, 1953; Thomas, 1971; Chao, 1978; Mercer, 1985).

Inner strata yielded a total of 53,412 weakfish (7.0 individuals/ha) weighing 3722 kg (0.5 kg/ha). In 1998 density of individuals reached the highest level in the history of the survey (Figure 23). Density varied significantly among years ($X^2 = 24.4$, $p < 0.005$), seasons ($X^2 = 12.2$, $p < 0.005$), and regions ($X^2 = 109.7$, $p < 0.0001$). Overall density was greatest in spring and decreased in subsequent seasons (Table 7), with more than 56% of all weakfish taken in inner strata during the spring cruises. Weakfish were most abundant in the northern portion of the SAB, with density of individuals decreasing with decreasing latitude. Outer strata produced 2525 specimens (spring: n = 862, $\bar{X}$/ha = 0.80; fall: n = 1663, $\bar{X}$/ha = 2.81)

Total lengths of *Cynoscion regalis* ranged from 6 to 42 cm ($\bar{X} = 18.9$, n = 51,852). Length was significantly different among seasons ($X^2 = 184$, $p < 0.0001$). Mean length decreased from spring to summer, indicating the recruitment of YOY individuals, and increased in fall as the result of subsequent juvenile growth (Figure 24).

Mean length also varied significantly among regions ($X^2 = 371$, $p < 0.0001$), with larger fish occurring in Onslow Bay and off Florida (Figure 25). The length-frequency distributions of weakfish in Raleigh, Onslow, and Long Bays comprised primarily individuals taken in spring. Seasonal abundance in the northern portion of the SAB decreased from spring to fall. Most of the smaller fish in those regions were collected in summer and the larger fish in fall collections. Less than 20% of all weakfish taken in inner strata were caught in the three southernmost regions. The distributions from South Carolina and Georgia represent fish taken primarily from summer trawls, whereas the majority of specimens from Florida waters were taken in fall. Mean length of weakfish was greatest in collections from waters off Florida.

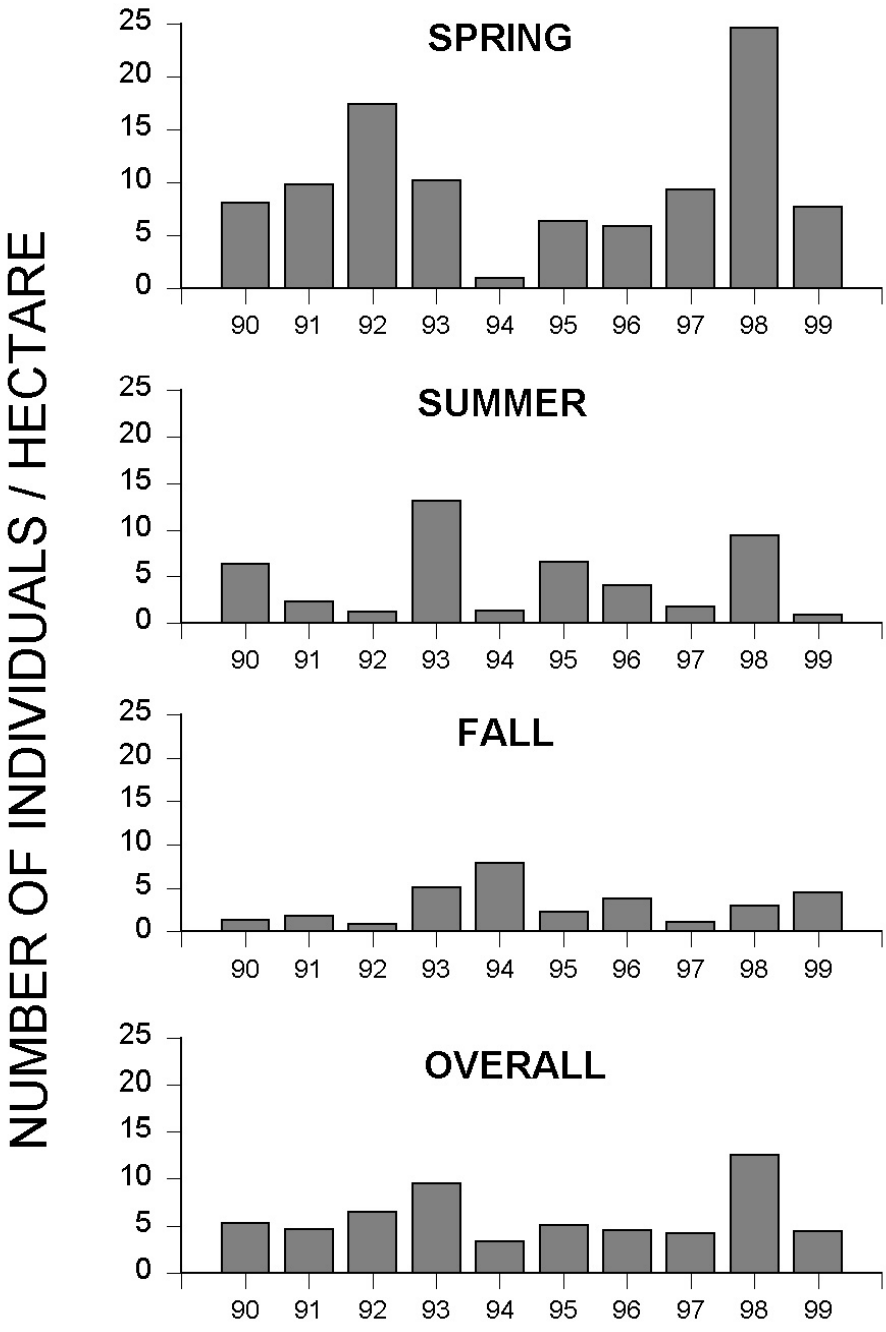



Figure 23. Annual densities of *Cynoscion regalis* from inner strata

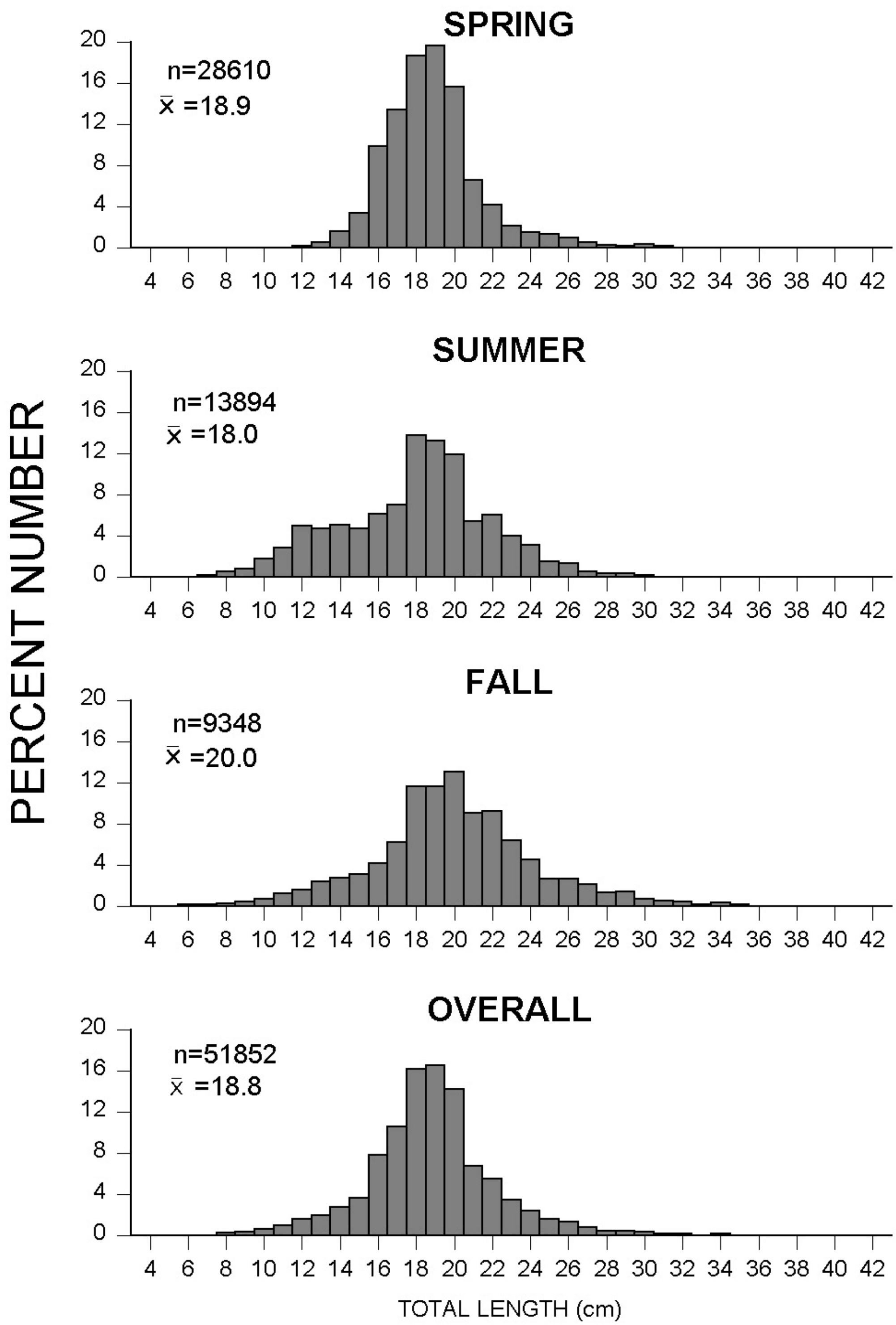



Figure 24. Seasonal length-frequencies of *Cynoscion regalis* from inner strata 1990-1999.

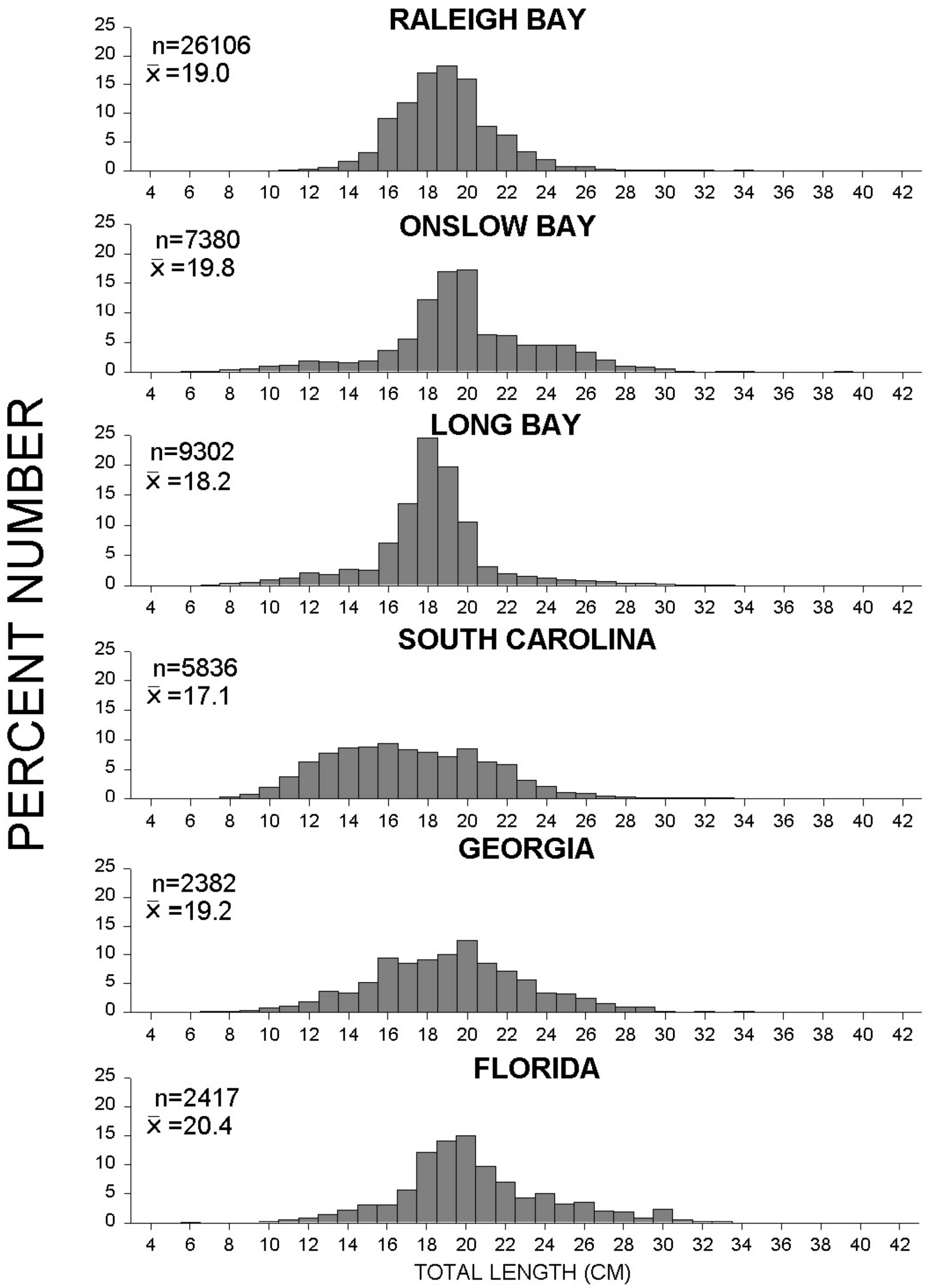



Figure 25. Regional length-frequencies of *Cynoscion regalis* in inner strata 1990-1999.

***Leiostomus xanthurus***

The spot ranges from Massachusetts throughout the Gulf of Mexico to the mouth of the Rio Grande (Chao, 1978) and is one of the most widely occurring and abundant fishes in the coastal waters of the South Atlantic Bight (Wenner and Sedberry, 1989). Spot migrate offshore to spawn in early November through late January (Flores-Coto and Warlen, 1993) and are subjected to heavy commercial and recreational fishing pressure at that time. Historically, the largest spot fishery has been the commercial gill-net fishery, which has contributed to the great fluctuations in commercial landings over the last 60 years (Mercer, 1989). Furthermore, recreational landings have been estimated to exceed commercial landings for the last several years (Office of Fisheries Management, South Carolina Department of Natural Resources).

*Leiostomus xanthurus* was the most abundant species collected by SEAMAP-SA from 1990 -1999 (Appendix 1). The 611,710 (73.9 individuals/ha) spot collected in the inner strata during that ten-year period weighed 37,585 kg (4.5 kg/ha) and constituted 20% of the total number of individuals taken in inner strata.

Density of individuals was found to vary significantly among years ($X^2 = 77.6$, $p < 0.0001$), seasons ($X^2 = 206.0$, $p < 0.0001$), and regions ($X^2 = 104.3$, $p < 0.0001$). Density peaked in 1990 and 1991 and reached its lowest levels in 1998 and 1999 (Figure 26). The greatest seasonal density of abundance occurred in the northern portion of the SAB in spring and in waters off Florida in summer (Table 7). Density of abundance peaked in spring, then declined to the lowest point in fall. The lowest regional density was observed in waters off Georgia. In the outer strata 49,519 spot were collected over the ten-year period (spring: n = 33156, $\bar{X}$/ha = 30.8; fall: n = 16363, $\bar{X}$/ha = 27.6). As with inner strata, the majority (67%) were taken in spring; however, they came from the southern SAB.

Total lengths of spot from the SEAMAP-SA survey (1990 -1999) ranged from 5 to 30 cm in inner strata, with a mean length of 16.1 cm (n = 610,930). Spot collected appeared to be fish of ages 0, I and II. Lengths varied significantly among seasons ($X^2 = 849$, $p < 0.0001$). The mean length of spot increased from spring to fall (Figure 27).

Length also varied significantly among regions ($X^2 = 770$, $p < 0.0001$). The length-frequency distribution of spot represents primarily specimens captured during the spring cruises. In the northern regions (Raleigh Bay, Onslow Bay, Long, Bay, South Carolina), with the exception of a few individuals, smaller specimens in the length-frequency distribution were collected during summer. Larger specimens were collected during fall. In waters off Georgia and Florida, smaller specimens were taken in both spring and summer and larger fish were taken during all three seasons. The mean length of spot was greatest in the southern portion of the SAB, with Florida waters producing the greatest regional mean length (Figure 28).

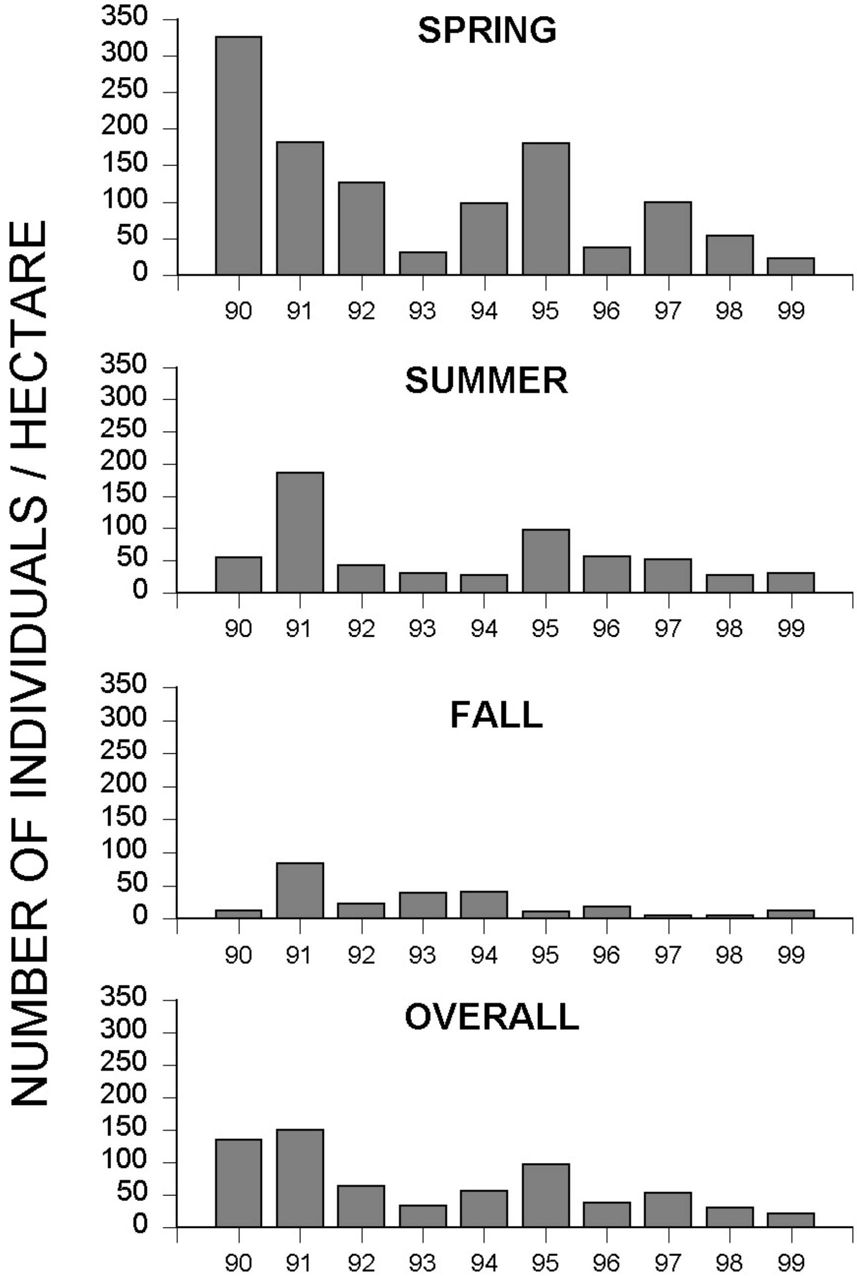



Figure 26. Annual densities of *Leiostomus xanthurus* from inner strata

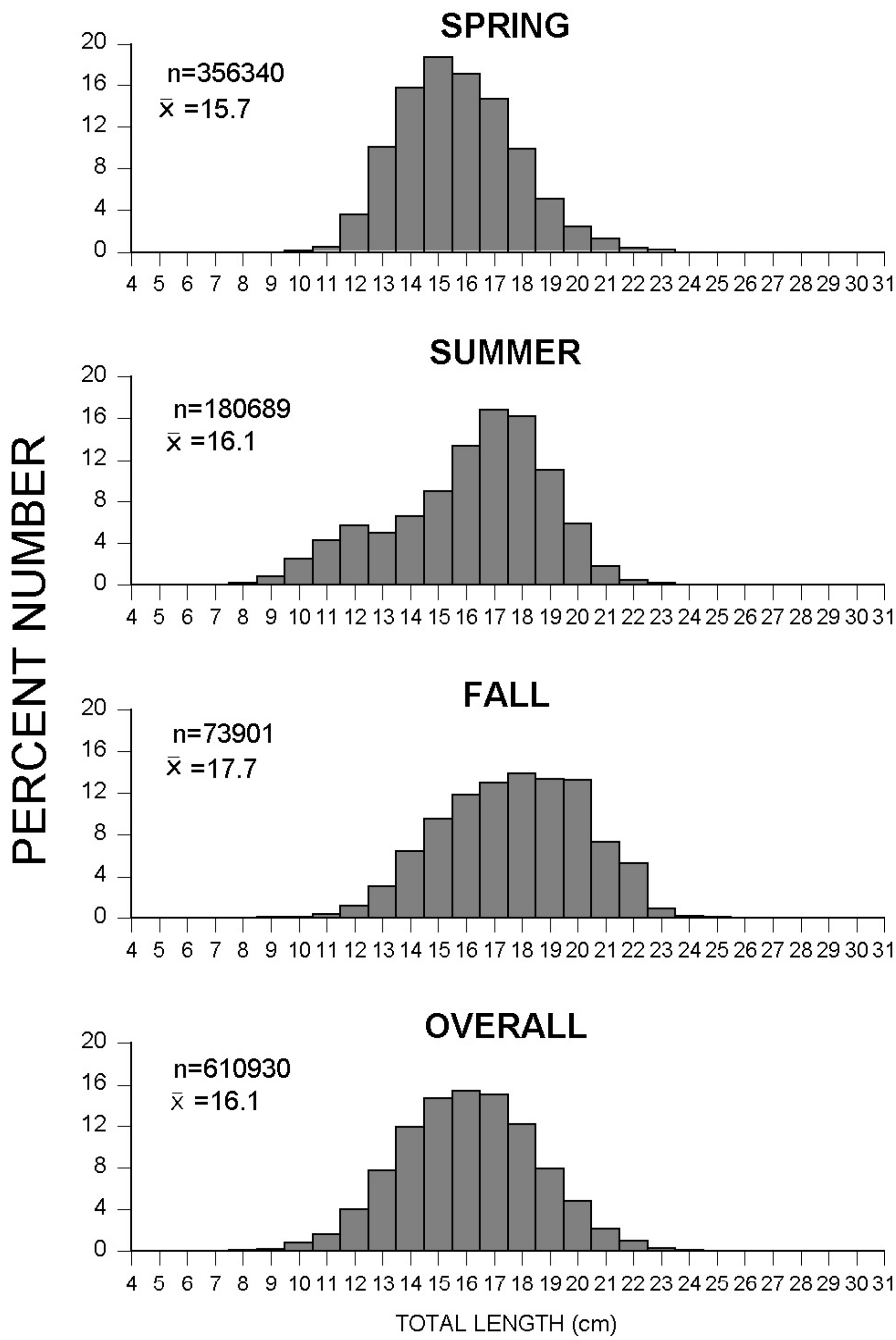



Figure 27. Seasonal length-frequencies of *Leiostomus xanthurus* from inner strata 1990-1999.

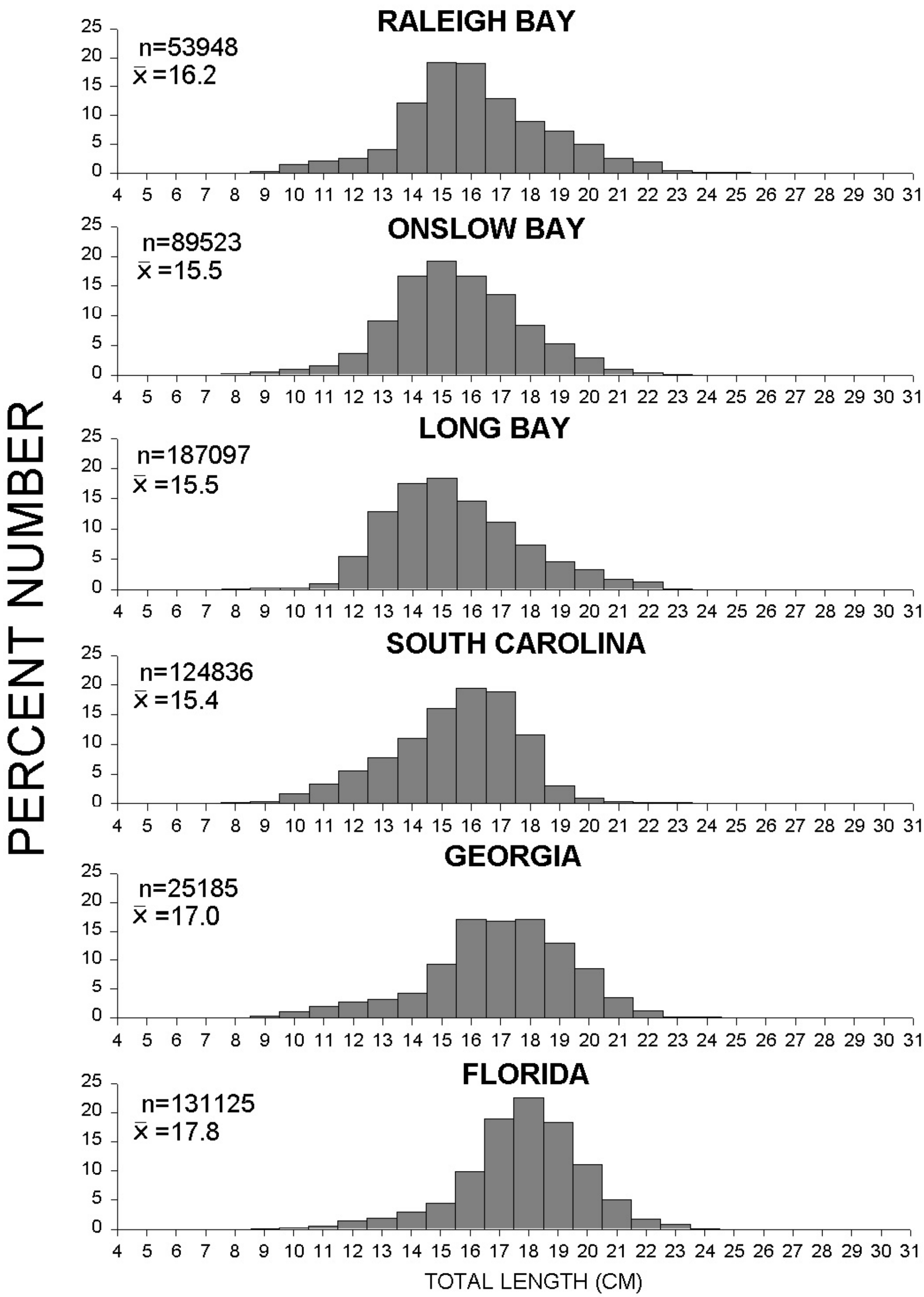



Figure 28. Regional length-frequencies of *Leiostomus xanthurus* in inner strata 1990-1999.

***Menticirrhus americanus***

The southern kingfish ranges from New England to Brazil (Chao 1978) and is the most abundant species in the genus occurring in the South Atlantic Bight. Southern kingfish attain the largest maximum body size of the three species of *Menticirrhus* and are important both commercially and recreationally.

The southern kingfish, *Menticirrhus americanus*, was the third most abundant target finfish, ranking 13th overall and 11th in inner strata. Inner strata produced a total of 67,381 southern kingfish (8.2 individuals/ha) weighing 6707 (0.8 kg/ha). Although density of individuals did not fluctuate a great deal annually, density did peak in 1990-91 and 1996 (Figure 29) and was found to be significantly different among years ($X^2 = 22.3$, $p < 0.01$), seasons ($X^2 = 18.0$, $p < 0.0001$), and regions ($X^2 = 192.4$, $p < 0.0001$). Density was greatest in fall and at the extremes of the geographical range of the survey (Raleigh Bay and Florida) (Table 7). The southern kingfish exhibited the highest percent occurrence of all priority species, being present in approximately 74% of all tows. Outer strata produced 5,867 specimens (spring: n = 3795, $\bar{X}$/ha = 3.52; fall: n = 2072, $\bar{X}$/ha = 3.50).

Total lengths of *Menticirrhus americanus* ranged from 4 to 48 cm ($\bar{X} = 20.7$, n = 67,381). Length was significantly different among seasons ($X^2 = 433$, $p < 0.0001$). Mean length decreased from summer to fall, representing the recruitment of YOY individuals (Figure 30). Length also varied significantly among regions ($X^2 = 213$, $p < 0.0001$), with larger fish occurring in the northern SAB and off Florida (Figure 31). The seasonal length-frequency distributions of southern kingfish were similar throughout the SAB, with most of the smaller fish collected in summer and fall collections. Regions in the southern SAB comprised approximately 75% of all southern kingfish taken from inner strata.

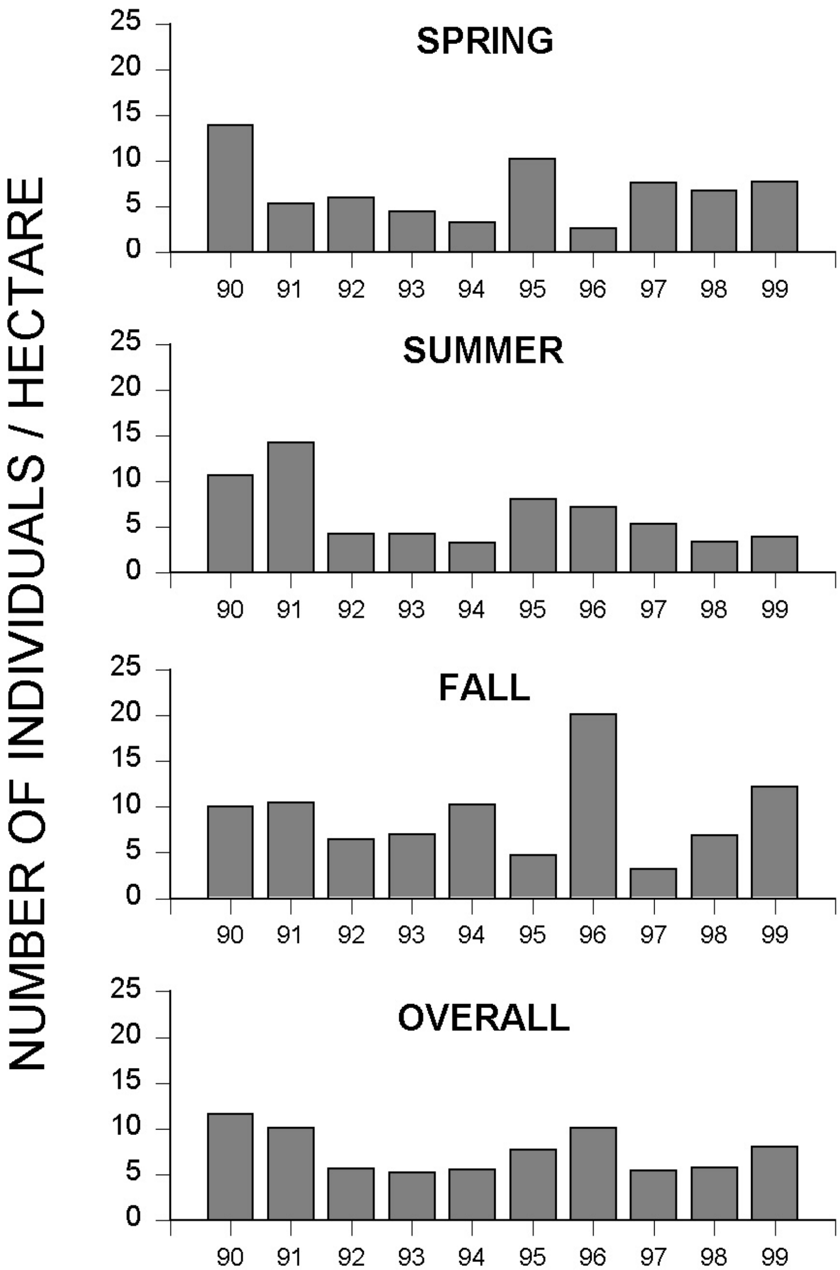



Figure 29. Annual densities of *Menticirrhus americanus* from inner strata

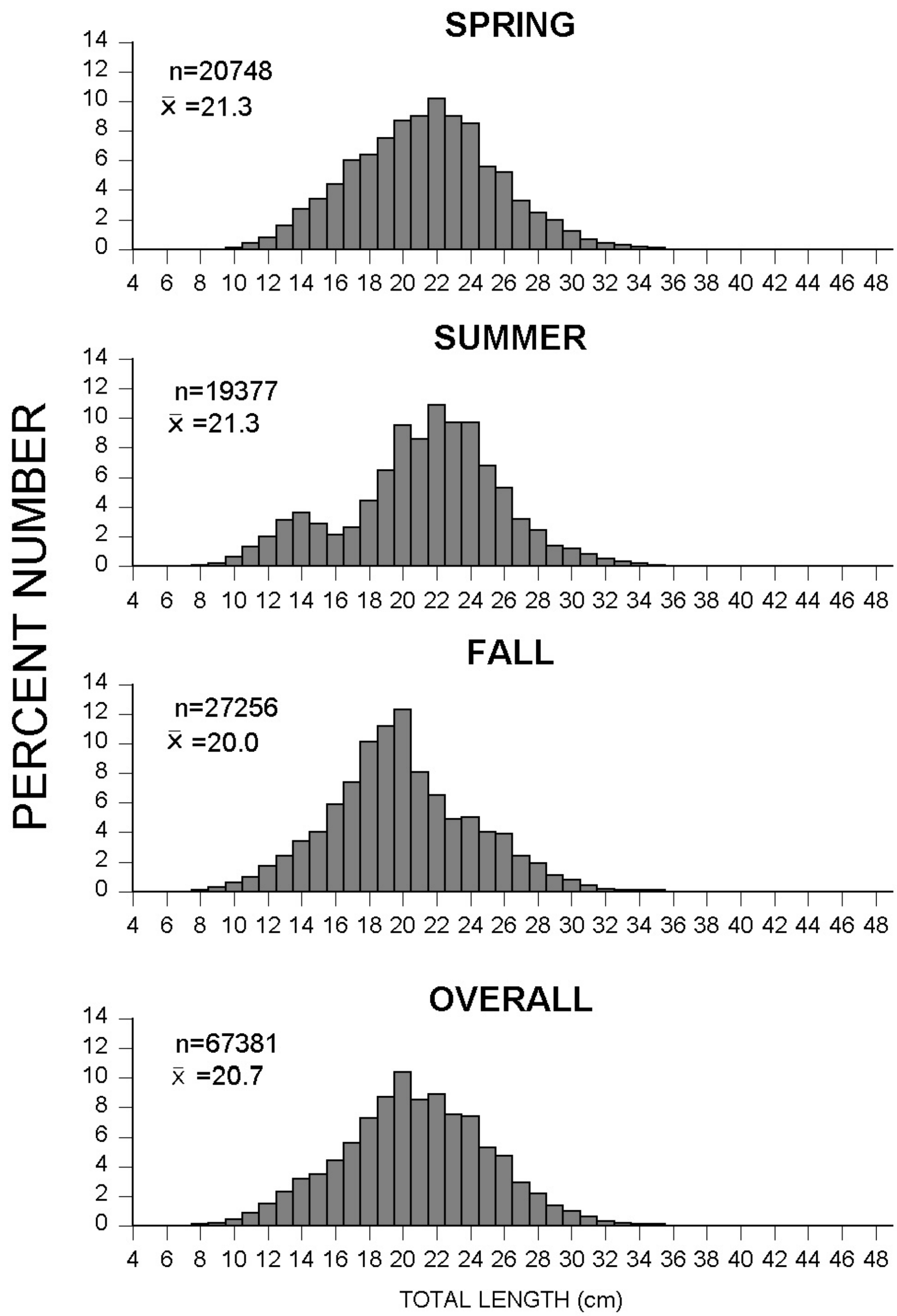



Figure 30. Seasonal length-frequencies of *Menticirrhus americanus* from inner strata 1990-1999.

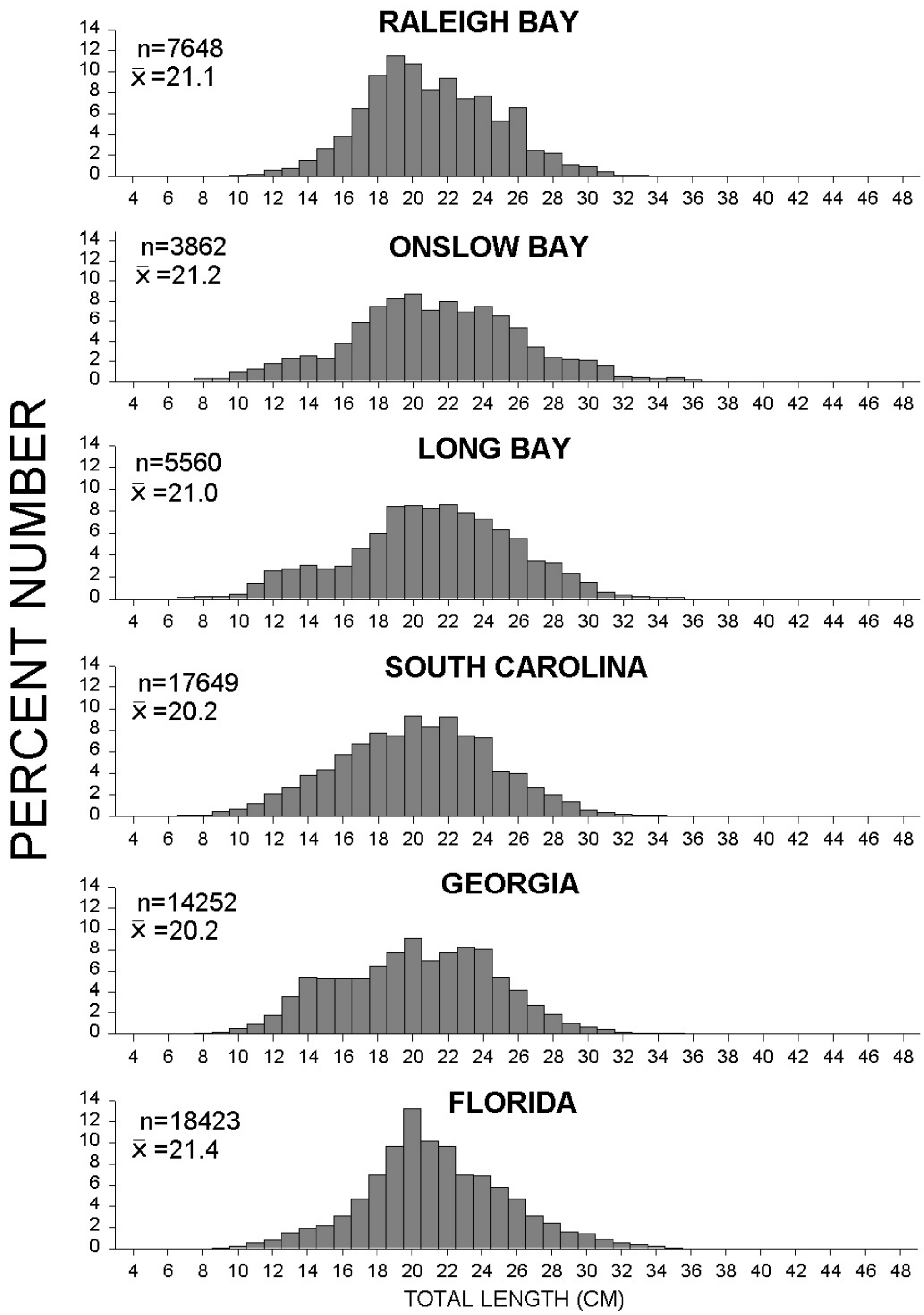



Figure 31. Regional length-frequencies of *Menticirrhus americanus* in inner strata 1990-1999.

## *Menticirrhus littoralis*

Gulf kingfish are found along the western Atlantic coast from the Chesapeake Bay to south Florida as well as the Gulf of Mexico, Central American, and S. American coasts from south Florida to Rio Grande, Brazil (Chao, 1978). This species is a bottom feeder and is found over muddy and sandy bottom in coastal waters, but is also abundant in the surf zone. The young of this species can sometimes be found in the estuaries.

Inner strata yielded a total of 1517 gulf kingfish (0.2 individuals/ha) weighing 240 kg (0.03 kg/ha). Density of individuals was at the highest level in the history of the SEAMAP-SA project in 1996 (Figure 32), due to a record catch of gulf kingfish in the fall of that year, and was found to differ significantly among years ($X^2 = 51.2$, $p < 0.0001$). Density was greatest in fall and lowest in spring (Table 7). Although densities of abundance did not differ significantly among seasons ($X^2 = 4.0$, $p > 0.1$), abundance was significantly different among regions ($X^2 = 29.1$, $p < 0.0001$). Gulf kingfish were most abundant in Florida waters. More than 75% of all gulf kingfish taken in inner strata were collected during fall cruises off Florida. Outer strata produced only 28 specimens (spring: n = 20, $\bar{X}$/ha = 0.02; fall: n = 8, $\bar{X}$/ha = 0.01).

Total lengths of *Menticirrhus littoralis* ranged from 10 to 44 cm ($\bar{X}$ = 24.4, n = 1514). Length was significantly different among seasons ($X^2 = 138$, $p < 0.0001$). Mean length decreased from summer to fall, indicating the recruitment of YOY individuals (Figure 33). Length also varied significantly among regions ($X^2 = 81$, $p < 0.0001$), with larger fish occurring off Georgia and Florida (Figure 34). The length-frequency distributions of Raleigh, Onslow, and Long Bays represent less than 10% of all gulf kingfish taken from inner strata, with most of the smaller fish collected in spring and the larger fish in fall collections. The distributions from waters off South Carolina, Georgia, and Florida Onslow and Long Bays represent fish taken primarily from fall trawls, when the majority of the smaller individuals were taken. More than 75% of all gulf kingfish taken in inner strata were caught in Florida waters.

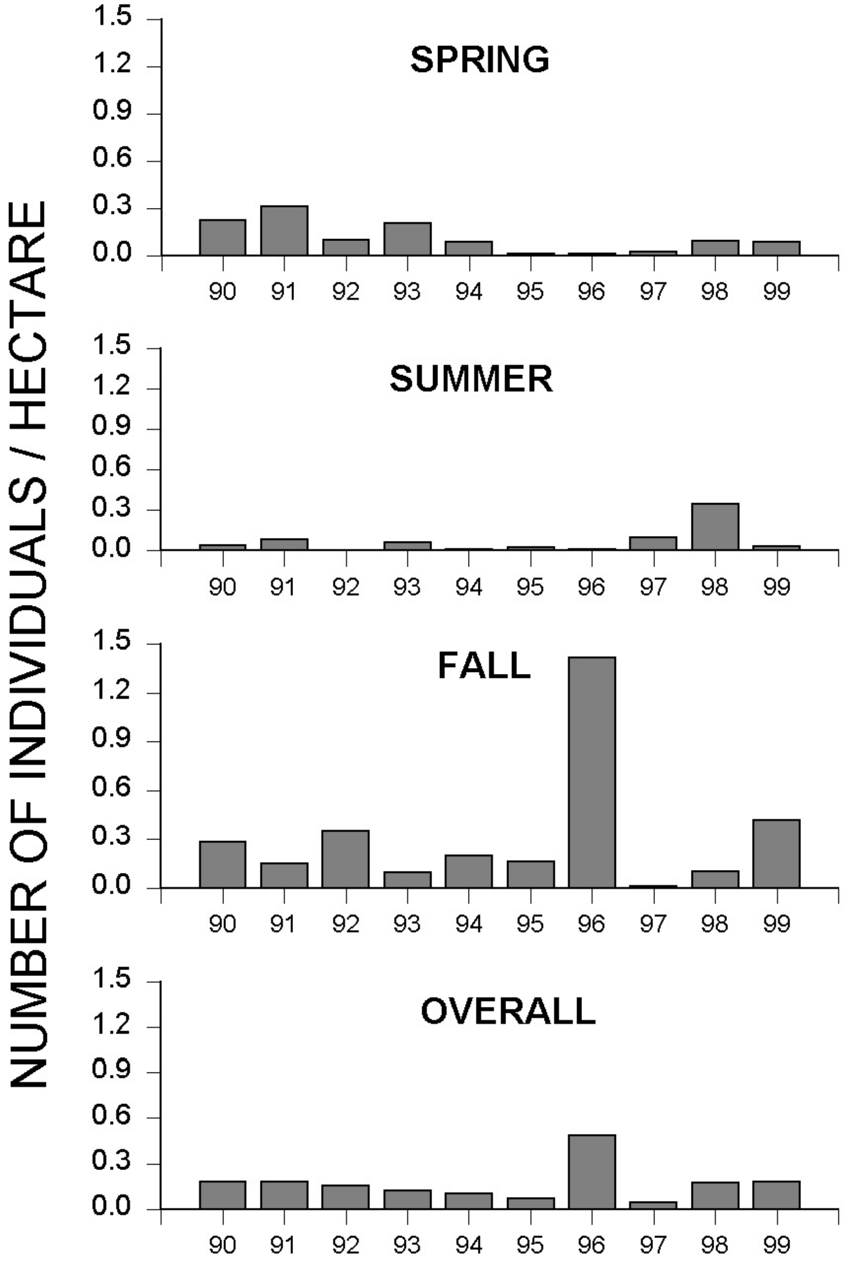



Figure 32. Annual densities of *Menticirrhus littoralis* from inner strata

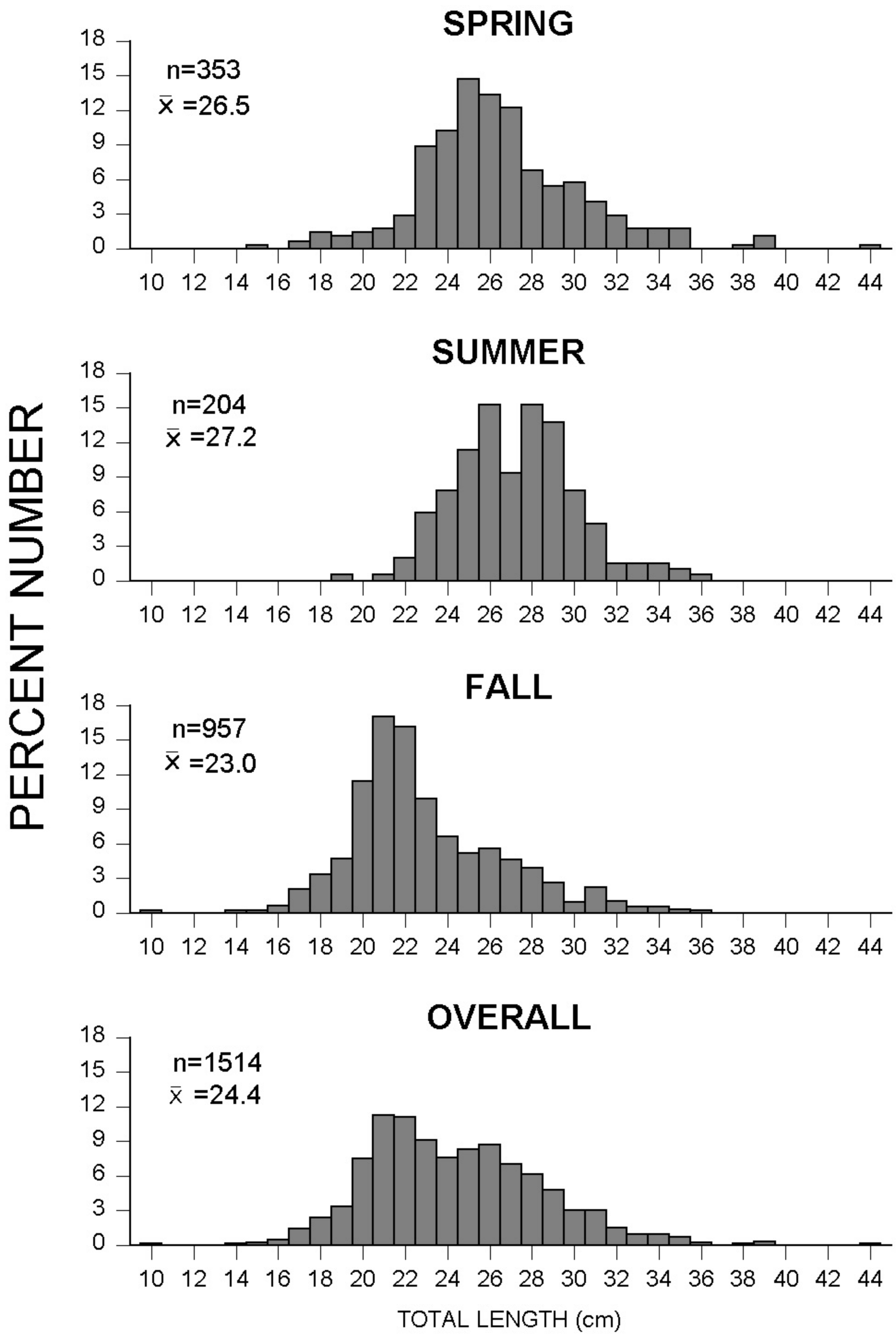



Figure 33. Seasonal length-frequencies of *Menticirrhus littoralis* from inner strata 1990-1999.

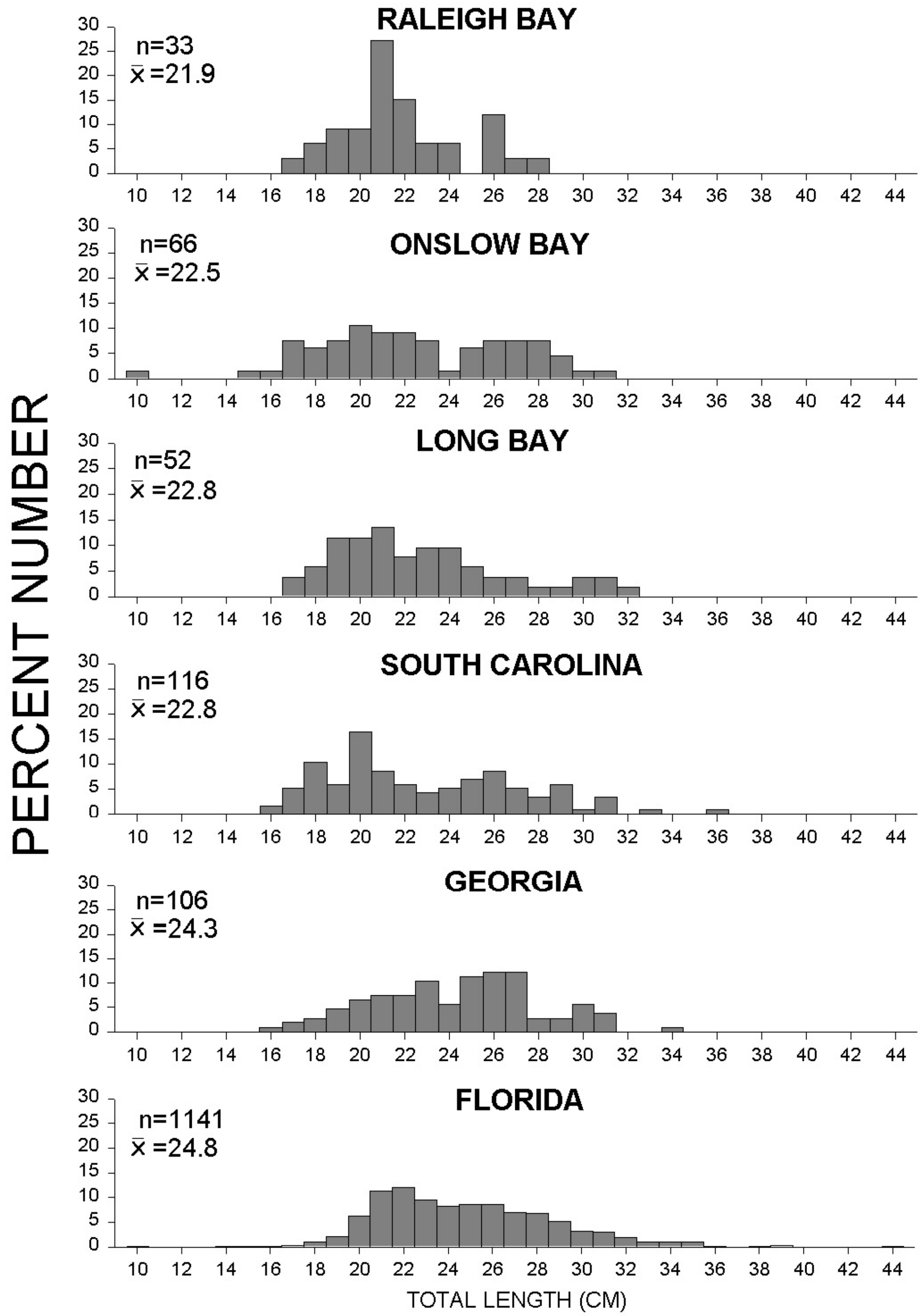



Figure 34. Regional length-frequencies of *Menticirrhus littoralis* in inner strata 1990-1999.

***Menticirrhus saxatilis***

Northern kingfish inhabit the western Atlantic and Gulf of Mexico coasts from the Gulf of Maine to the Yucatan this fish can be found bottom feeding over sandy and muddy bottoms in near shore waters, as well as being prominent in the surf zone (Chao, 1978). Young may be found in the estuaries.

Inner strata yielded a total of 1020 northern kingfish (0.1 individuals/ha) weighing 130 kg (0.02 kg/ha). Density of individuals has declined since the beginning of the survey, with the exception of 1996 when a secondary peak in abundance was observed (Figure 35). Density was greatest in spring and fall (Table 7). Although densities of abundance did not differ significantly among years ($X^2 = 14.7$, $p = 0.1$) or seasons ($X^2 = 5.6$, $p > 0.06$), abundance was significantly different among regions ($X^2 = 68.7$, $p < 0.0001$). Northern kingfish were most abundant in the northern portion of the SAB. Density of individuals was greatest in Raleigh Bay, where approximately 78% of all northern kingfish were collected in inner strata. Outer strata produced 260 specimens, all of which were taken in fall collections in the northern SAB ($n = 259$, $\overline{X}$/ha = 0.44), with the exception of one individuals taken in spring.

Total lengths of *Menticirrhus saxatilis* ranged from 8 to 36 cm ($\overline{X} = 23.6$, $n = 1017$). Length was significantly different among seasons ($X^2 = 108$, $p < 0.05$). Mean length decreased from spring to summer, indicating the recruitment of YOY individuals, and increased in fall as the result of subsequent juvenile growth (Figure 36). Mean length also varied significantly among regions ($X^2 = 14$, $p < 0.0001$), with larger fish occurring in the northern SAB and off Georgia (Figure 37). The length-frequency distribution of northern kingfish in Raleigh Bay represents approximately 78% of all northern kingfish taken from inner strata, with most of the smaller fish collected in summer and the larger fish in spring and fall collections. Only 2% of the northern kingfish from Raleigh Bay were caught in summer. The smaller individuals in the regional length-frequency distributions from Onslow and Long Bays were taken in summer and larger individuals in spring and fall. Approximately 2% of all northern kingfish taken in inner strata were caught in the three southernmost regions. With the exception of one individual, all northern kingfish from the southern SAB were taken in summer. Mean lengths of northern kingfish were greatest in collections from Raleigh Bay, Long Bay, and Georgia.

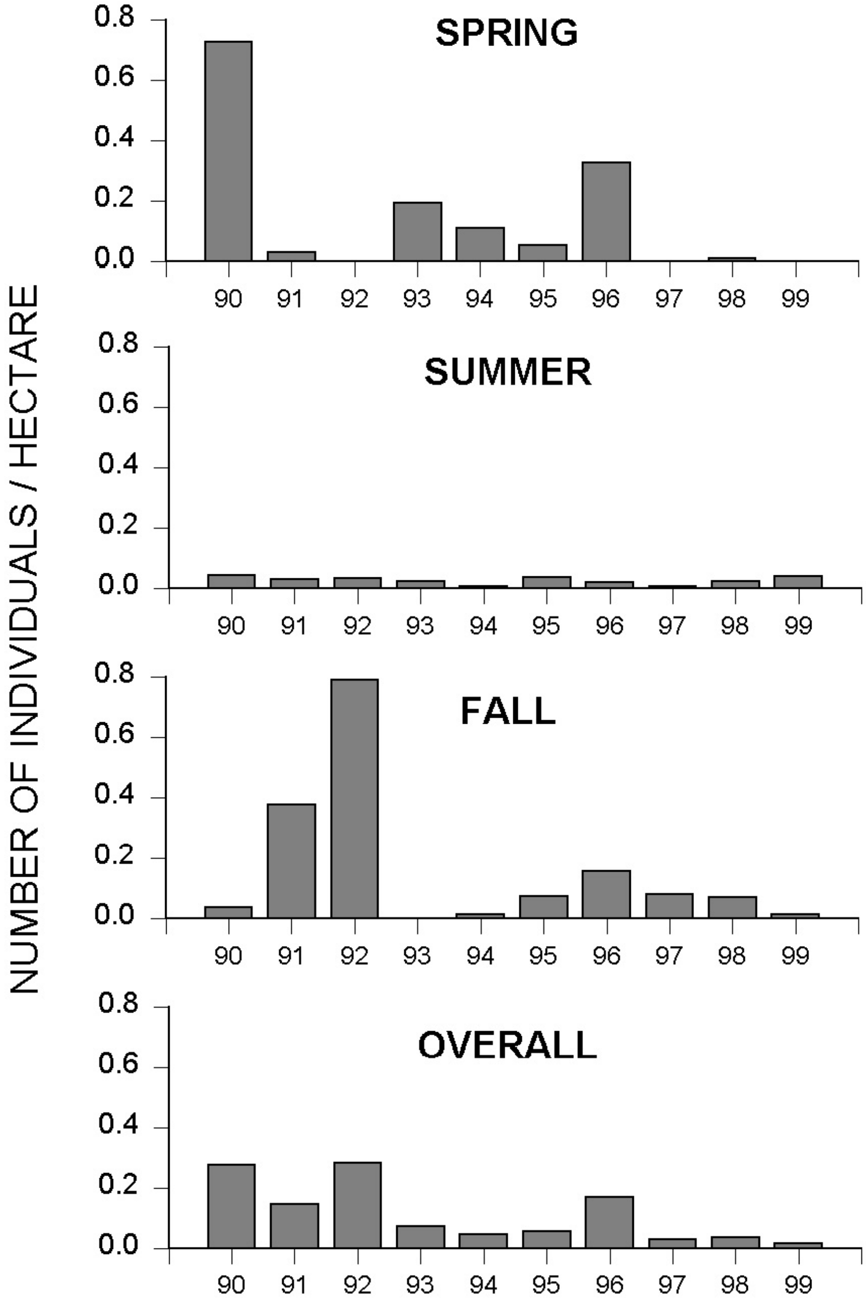



Figure 35. Annual densities of *Menticirrhus saxatilis* from inner strata

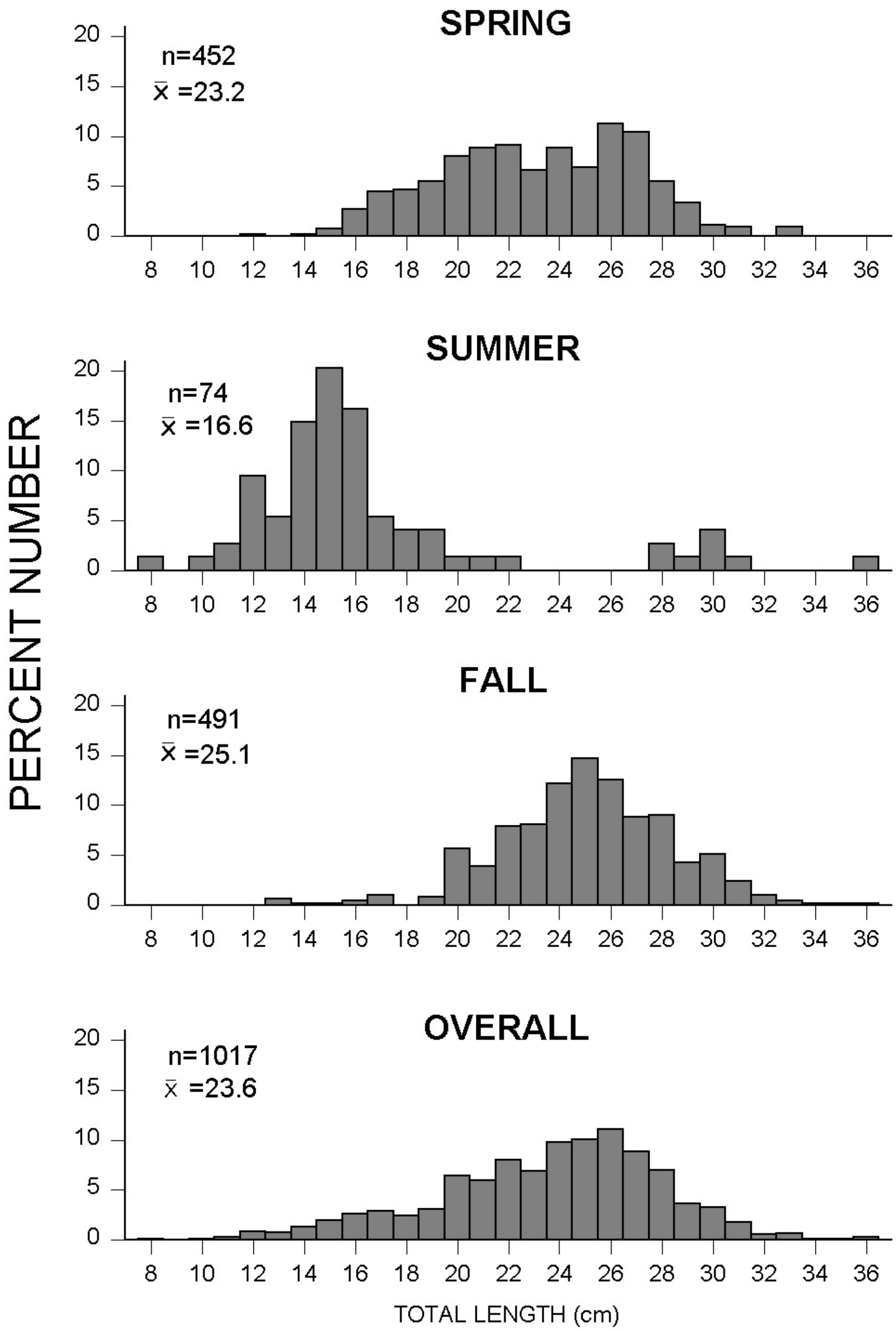



Figure 36. Seasonal length-frequencies of *Menticirrhus saxatilis* from inner strata 1990-1999.

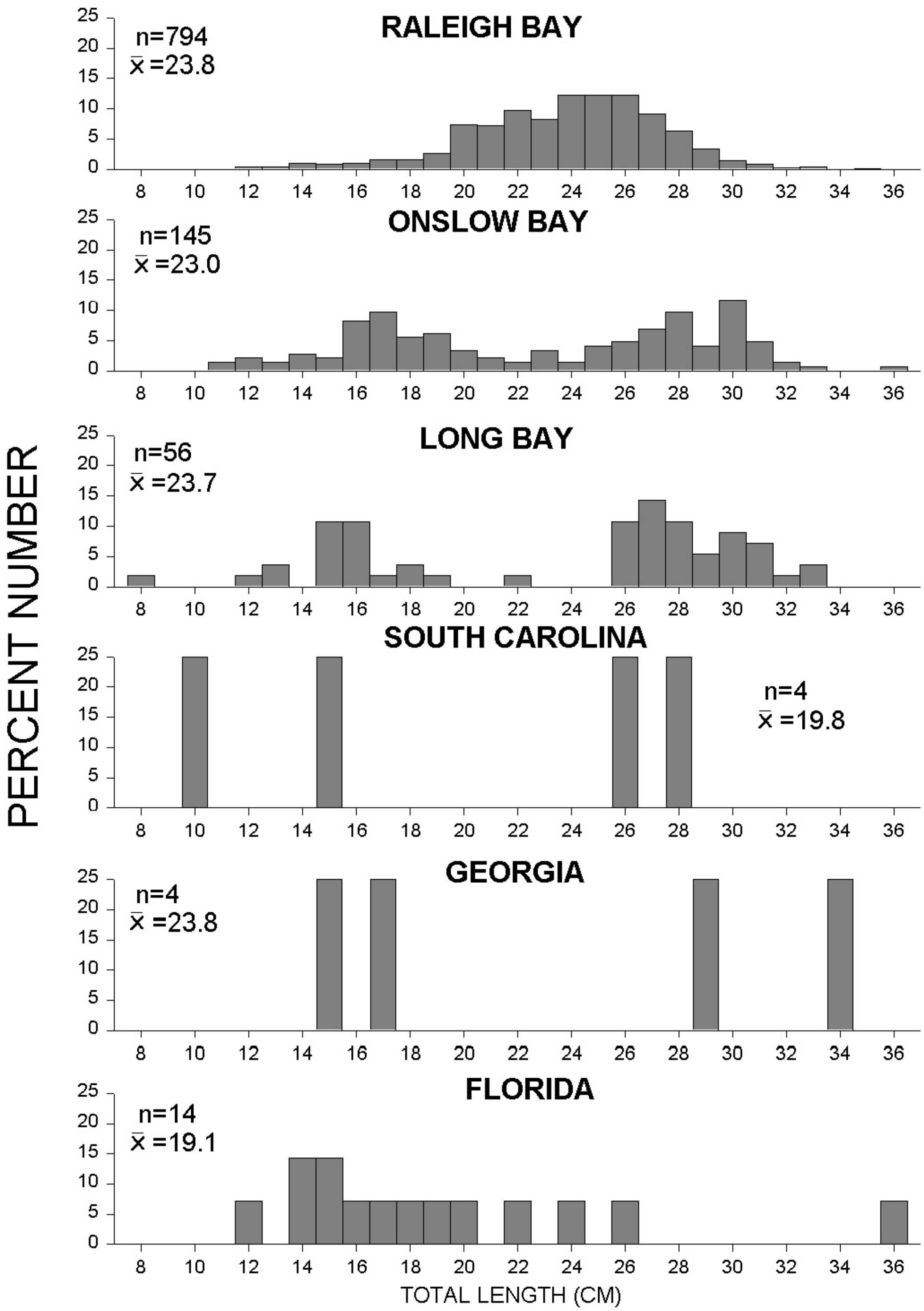



Figure 37. Regional length-frequencies of *Menticirrhus saxatilis* in inner strata 1990-1999.

## *Micropogonias undulatus*

The Atlantic croaker ranges from Argentina to the Gulf of Maine (Chao, 1978). This species is one of the most abundant finfish species in trawl catches in the SAB (Wenner and Sedberry, 1989) and is considered to be an excellent food fish. In addition to trawls, croaker are also caught with pound nets, gill-nets, trammel nets and seines, and also on hook-and-line by sports fishermen (Chao, 1978).

*Micropogonias undulatus* was the second most abundant species collected in SEAMAP-SA samples (1990 - 1999). The 552,994 individuals (31605 kg) made up18%of the total number of specimens taken in inner strata. Density estimates for the inner strata over the entire SAB were 64.2 individuals/ha and 3.7 kg/ha. Density was found to vary significantly among years ($X^2 = 29.2$, $p = 0.0006$), seasons ($X^2 = 57.2$, $p < 0.0001$), and regions ($X^2 = 105.3$, $p < 0.0001$). Density of individuals peaked in 1991-1992 and dipped to the lowest level in 1997 (Figure 38). The highest regional and seasonal densities of individuals occurred in Raleigh Bay in spring and fall (Table 7). Highest overall regional density occurred in Raleigh Bay. Regional densities were greatest in spring in the northernmost strata (Raleigh Bay, Onslow Bay, and Long Bay) and in summer in the southernmost regions (South Carolina, Georgia, and Florida). Outer strata produced 60,004 specimens (spring: n = 32117, $\overline{X}$/ha = 29.8; fall: n = 27927, $\overline{X}$/ha = 47.2).

Total lengths of Atlantic croaker from inner strata ranged from 4 to 32 cm ($\overline{X}$ = 17.3 cm, n = 552,951). Lengths differed significantly among seasons ($X^2 = 176$, $p < 0.0001$). The mean length of Atlantic croaker increased from summer to fall (Figure 39). The spring length-frequency distribution appeared to comprise mostly Age I and a few Age II fish. The inclusion of smaller specimens in summer collections resulted in a length-frequency distribution representing mostly Age I fish that were spawned late and some YOY specimens. Fall collections consisted of mostly Age I, YOY, and a few Age II fish.

Based on length-at-age data, in all seasons the numerically dominant fish were probably Age 0 and Age I, with a few Age II fish present, primarily in spring. Length also varied significantly among regions ($X^2 = 511$, $p < 0.0001$), and mean lengths ranged from 15.9 cm off South Carolina to 18.0 cm in Onslow Bay (Figure 40). The length-frequency distribution in Raleigh Bay comprised primarily (84%) of fish caught in spring and fall, with the majority of the smaller specimens taken in spring collections and the larger specimens in fall. In Onslow Bay, the length-frequency distributions were similar in all three seasons, with more small specimens taken in summer. In Long Bay, the number of species decreased from spring to fall, with smaller specimens taken in spring. The length-frequency distributions from South Carolina primarily represent fish caught in summer (66%); however, the smallest specimens were taken in spring. Smaller specimens from waters off Georgia and Florida were also taken in spring. The majority (68%) of the Atlantic croaker taken off Florida were caught during summer cruises; only 3% were collected in fall trawls.

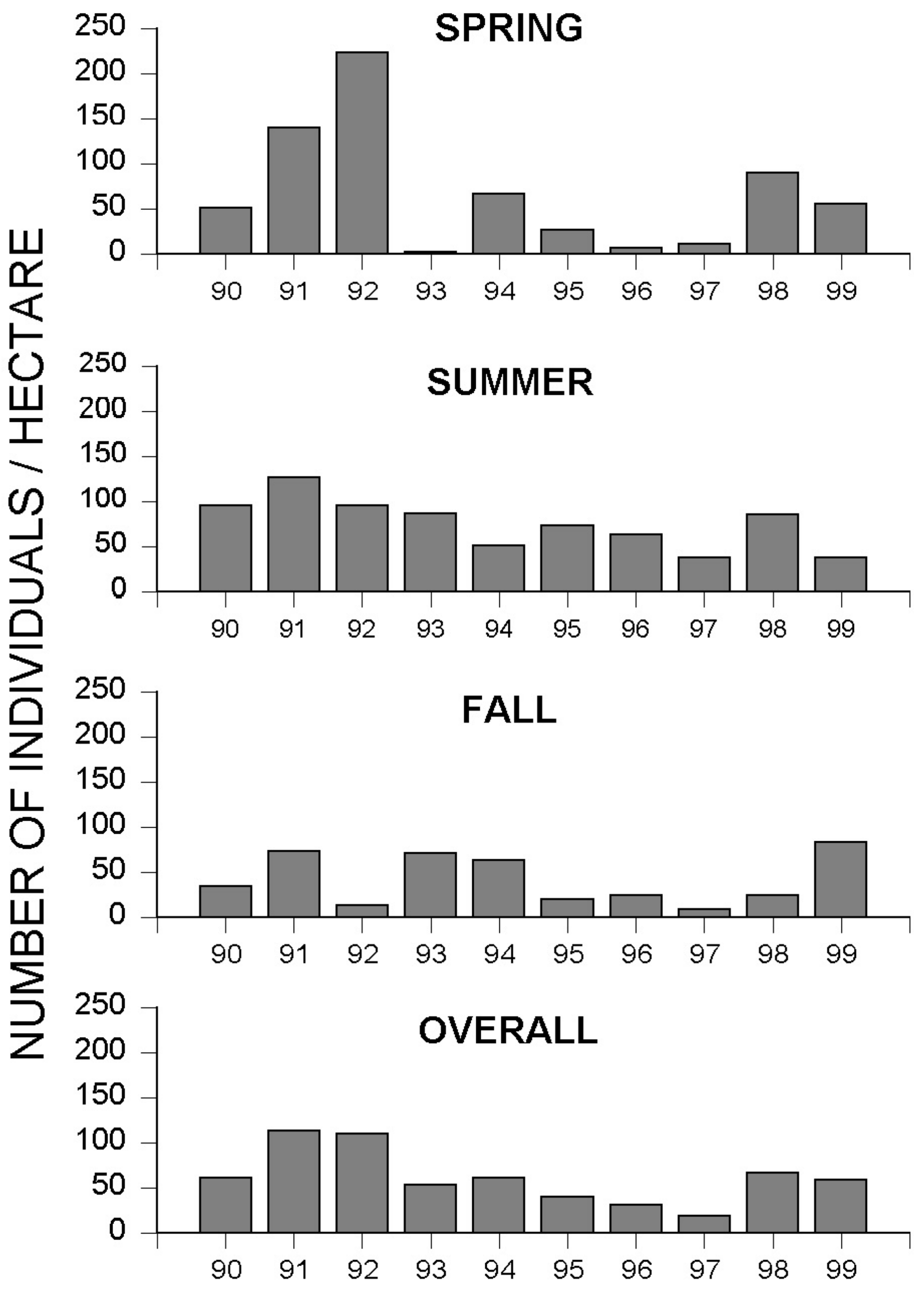



Figure 38. Annual densities of *Micropogonias undulatus* from inner strata

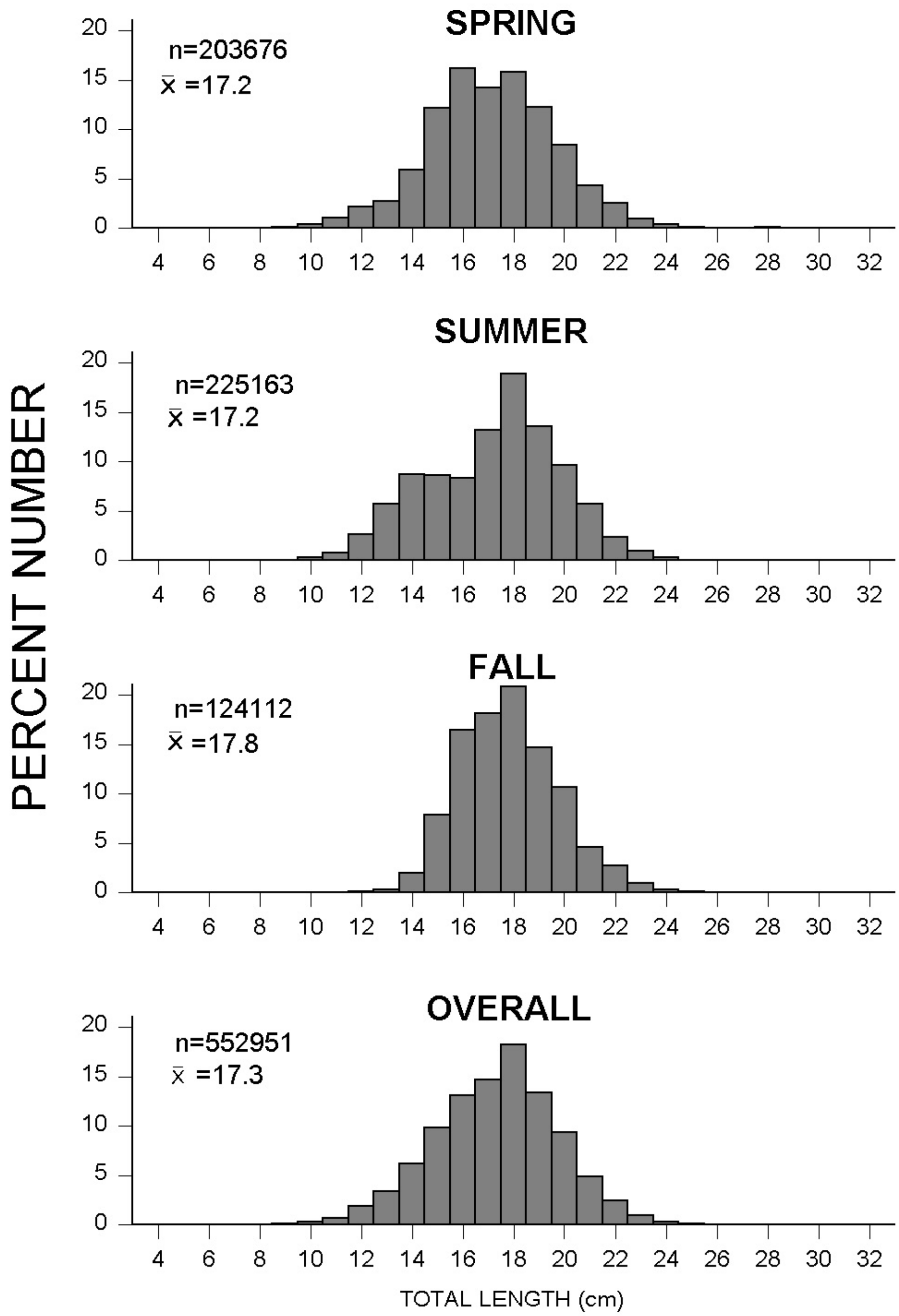



Figure 39. Seasonal length-frequencies of *Micropogonias undulatus* from inner strata 1990-1999.

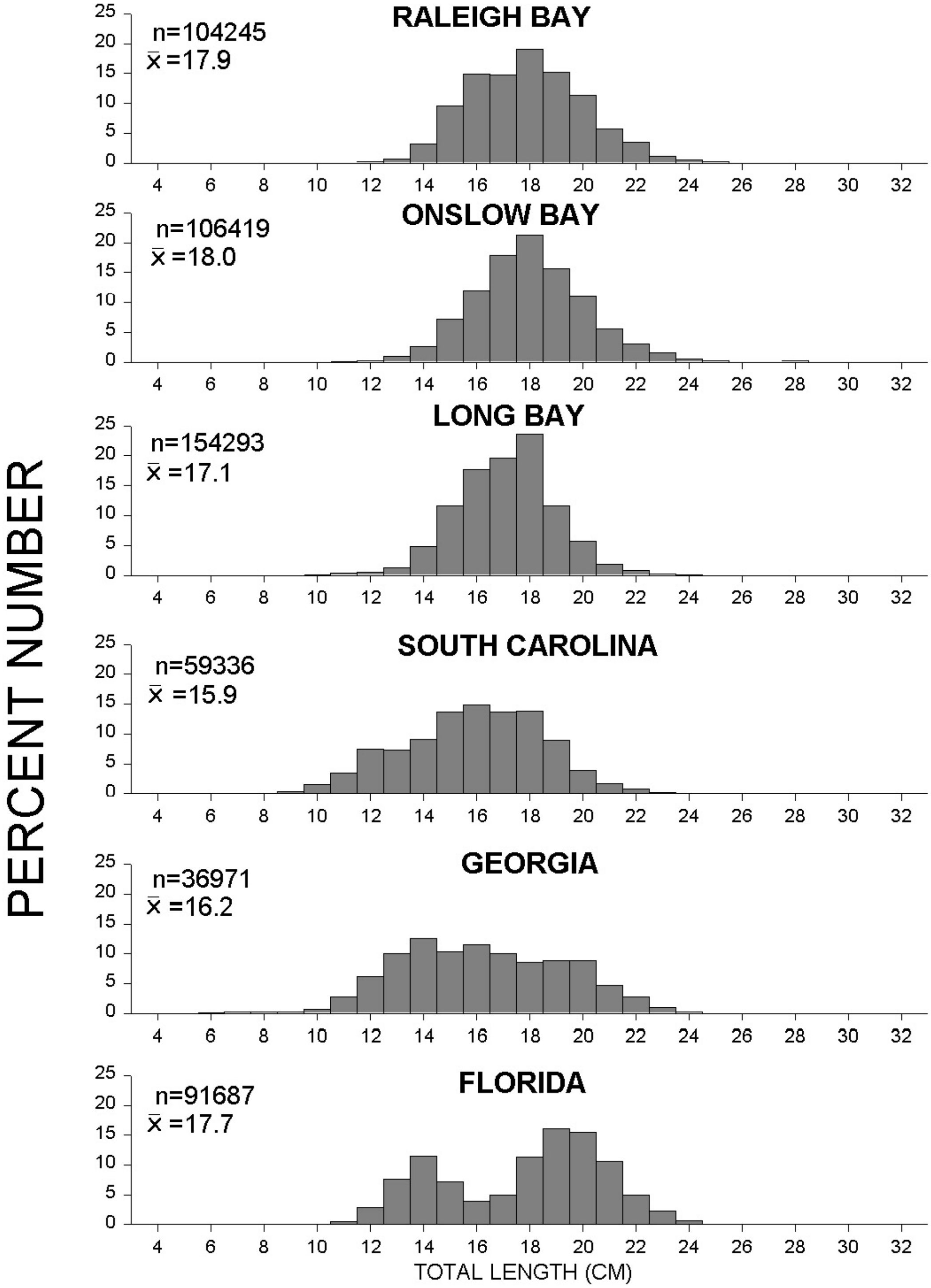



Figure 40. Regional length-frequencies of *Micropogonias undulatus* in inner strata 1990-1999.

***Mycteroperca microlepis***

The gag grouper is found along the western Atlantic coast of the Southeastern U.S. and is scarce in Bermuda (Smith, 1978).

The gag, *Mycteroperca microlepis*, was rare in SEAMAP-SA collections. Only 3 specimens were collected, all from fall cruises in inner strata. Gag were collected only in Raleigh and Onslow Bays (Table 7). Lengths ranged from 21 to 23 cm ($\bar{x}$ = 22.0).

***Paralichthys albigutta***

The gulf flounder is found along the western Atlantic and Gulf of Mexico coasts of the US from North Carolina to Texas, and is generally found in depths less than 150 meters (Gutherz, 1967; Randall and Vergara, 1978)

The gulf flounder, *Paralichthys albigutta*, exhibited low abundance in SEAMAP-SA collections. Only 163 individuals (0.02individuals/ha) weighing 38 kg (0.057 kg/ha) were taken in inner strata. Abundance of gulf flounder was greatest in 1992 and lowest in 1997-1998 (Figure 41). Density of individuals was found to vary significantly among years ($X^2$ = 37.1, $p < 0.0001$), seasons ($X^2$ = 10.1, $p < 0.01$), and regions ($X^2$ = 31.8, $p < 0.0001$). Gulf flounder were most abundant in summer and in Florida and Raleigh and Onslow Bays (Table 7). Lengths ranged from 15 to 54 cm ($\bar{x}$ = 26.4), with greatest mean length in spring (Figure 42) and variable regional means (Figure 43). Outer strata produced 102 specimens, the majority (89%) of which were taken in fall in the northern SAB (spring: n = 11, $\bar{x}$/ha = 0.01; fall: n = 91, $\bar{x}$/ha = 0.15).

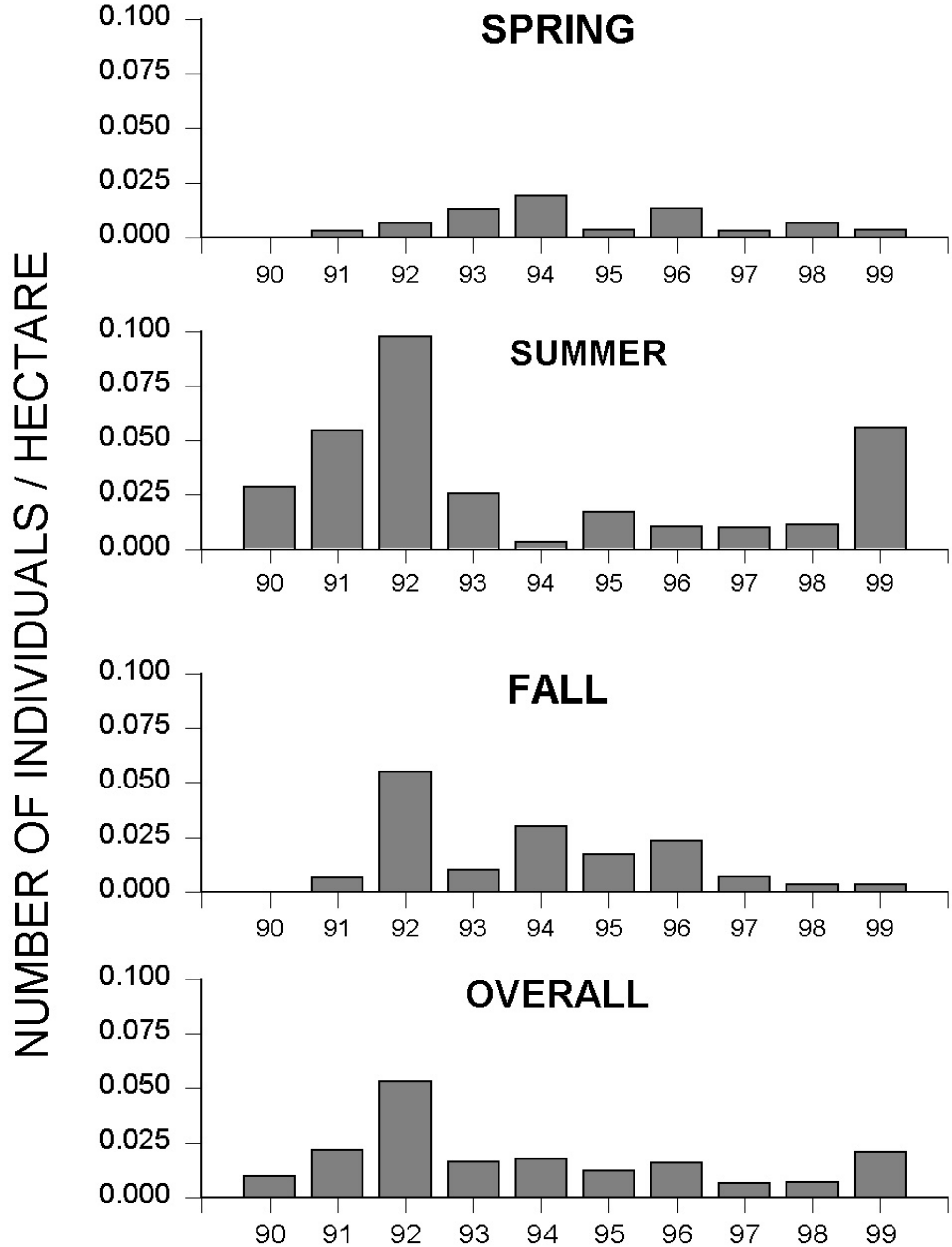



Figure 41. Annual densities of *Paralichthys albigutta* from inner strata

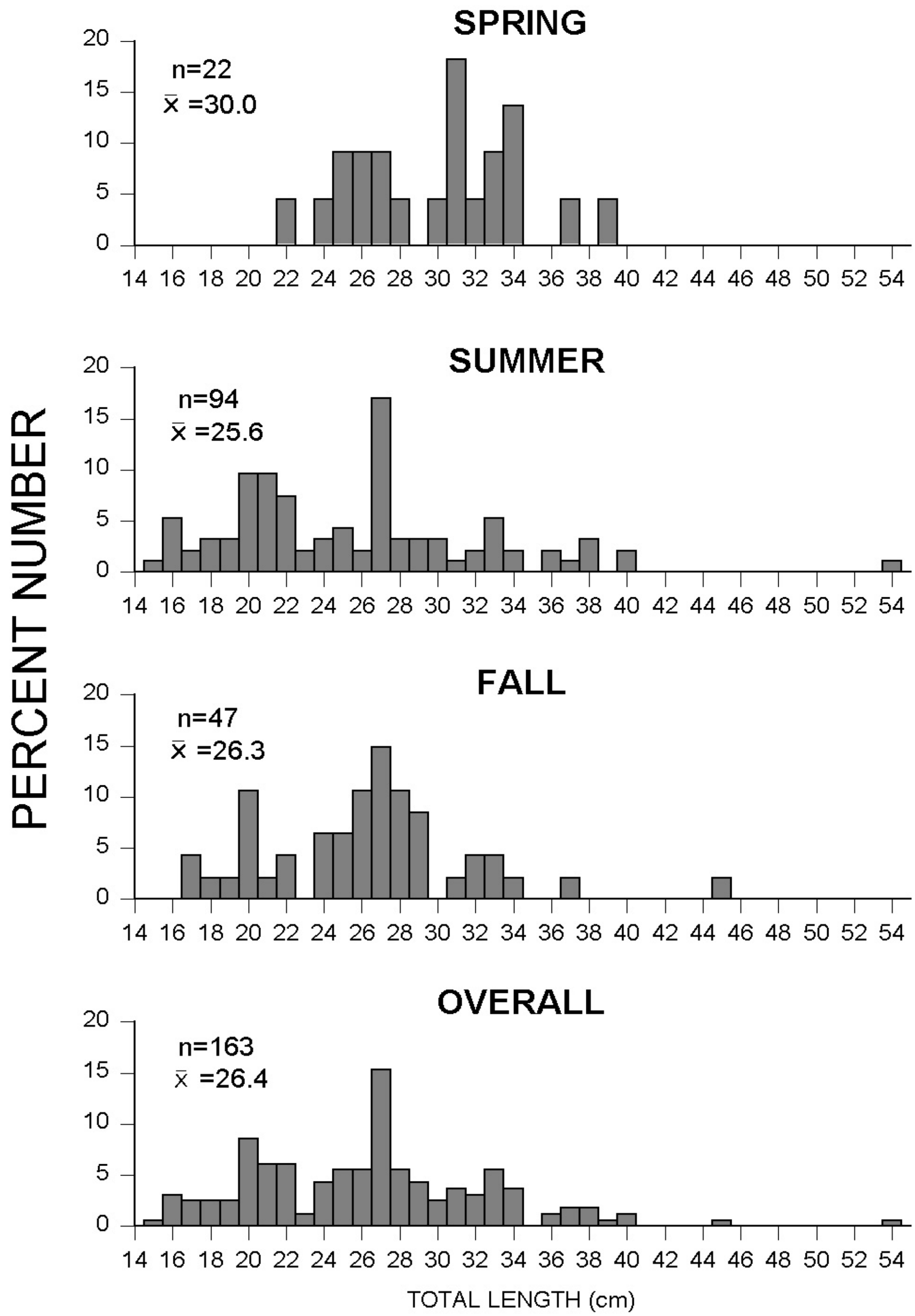



Figure 42. Seasonal length-frequencies of *Paralichthys albigutta* from inner strata 1990-1999.

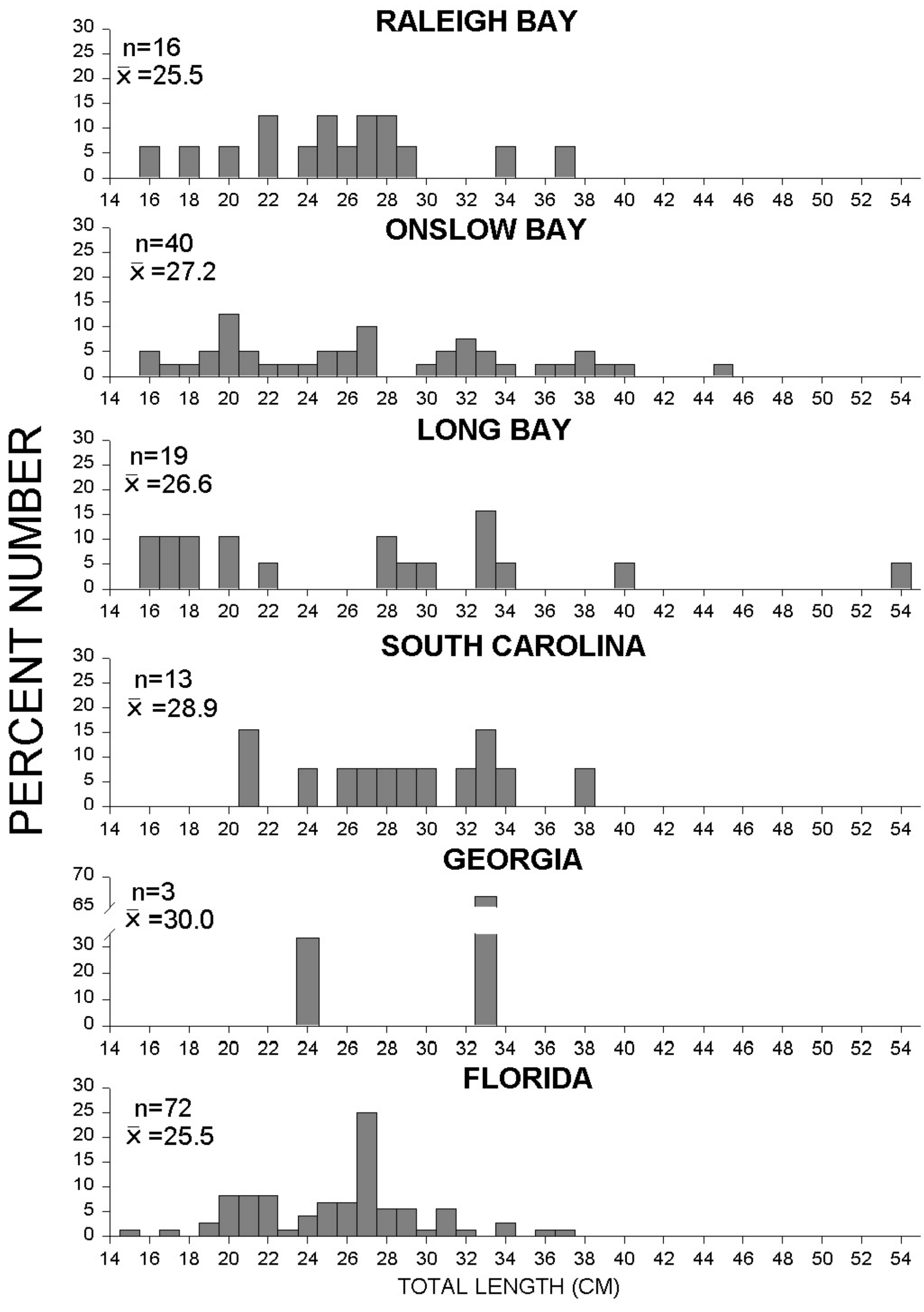



Figure 43. Regional length-frequencies of *Paralichthys albigutta* in inner strata 1990-1999.

### *Paralichthys dentatus*

Summer flounder are distributed along the Atlantic coast of the U.S., from Maine to Florida Gutherz, 1967; Randall and Vergara, 1978) Unlike *P. lethostigma*, which prefer muddy substrates in low salinity areas, summer flounder prefer sandy substrate in highly saline estuarine areas (Powell and Schwartz, 1977). Summer flounder are actively sought by both commercial and recreational fishermen and are taken year-round in South Carolina, incidental to the shrimp fishery (Keiser, 1976).

Inner strata yielded a total of 3856 summer flounder (0.4 individuals/ha) weighing 601 kg (0.07 kg/ha). Density of individuals did not vary much annually, with the exception of a peak in abundance in 1992 (Figure 44). Density was found to vary significantly among years ($X^2 = 65.2$, $p < 0.0001$), seasons ($X^2 = 12.4$, $p < 0.01$), and regions ($X^2 = 302.5$, $p < 0.0001$). Density was lowest in spring and increased in subsequent seasons (Table 7). Summer flounder were most abundant in the northern portion of the SAB, with density of individuals decreasing with decreasing latitude. Outer strata produced 305 specimens (spring: n = 67, $\bar{X}$/ha = 0.06; fall: n = 238, $\bar{X}$/ha = 0.40).

Total lengths of *Paralichthys dentatus* ranged from 8 to 51 cm ($\bar{X}$ = 24.2, n = 3853). Length was significantly different among seasons ($X^2 = 179$, $p < 0.0001$). Mean length decreased from spring to summer, indicating the recruitment of YOY individuals, and increased in fall as the result of subsequent juvenile growth (Figure 45). Mean length also varied significantly among regions ($X^2 = 187$, $p < 0.0001$), with larger fish occurring in Onslow Bay and off Florida (Figure 46).

### *Paralichthys lethostigma*

The southern flounder is a resident of the Atlantic and Gulf coasts of the U.S., and ranges from North Carolina to Texas (Randall and Vergara, 1978). Older juveniles and adults move offshore to deeper marine waters in the winter while juveniles (young-of-the-year) overwinter in the estuaries (Powell and Schwartz, 1977). *Paralichthys lethostigma* prefers muddy substrates in low salinity estuarine areas (Powell and Schwartz, 1977; Randall and Vergara, 1978).

Inner strata yielded a total of 489 southern flounder (0.06 individuals/ha) weighing 172 kg (0.02 kg/ha). Although density of individuals did not seem to vary much annually (Figure 47), density was found to vary significantly among years ($X^2 = 84.5$, $p < 0.0001$), seasons ($X^2 = 8.0$, $p < 0.05$), and regions ($X^2 = 105.1$, $p < 0.0001$). Density was greatest in fall and southern flounder were most abundant in the fall off South Carolina (Table 7). Outer strata produced 28 specimens (spring: n = 10, $\bar{X}$/ha = 0.01; fall: n = 18, $\bar{X}$/ha = 0.03).

Total lengths of *Paralichthys lethostigma* ranged from 13 to 55 cm ($\bar{X}$ = 30.6, n = 489). Length was significantly different among seasons ($X^2 = 6.5$, $p < 0.05$), although seasonal mean length did not vary much overall (Figure 48). Mean length also varied significantly among regions ($X^2 = 27$, $p < 0.0001$), with larger fish occurring off Georgia and Florida (Figure 49).

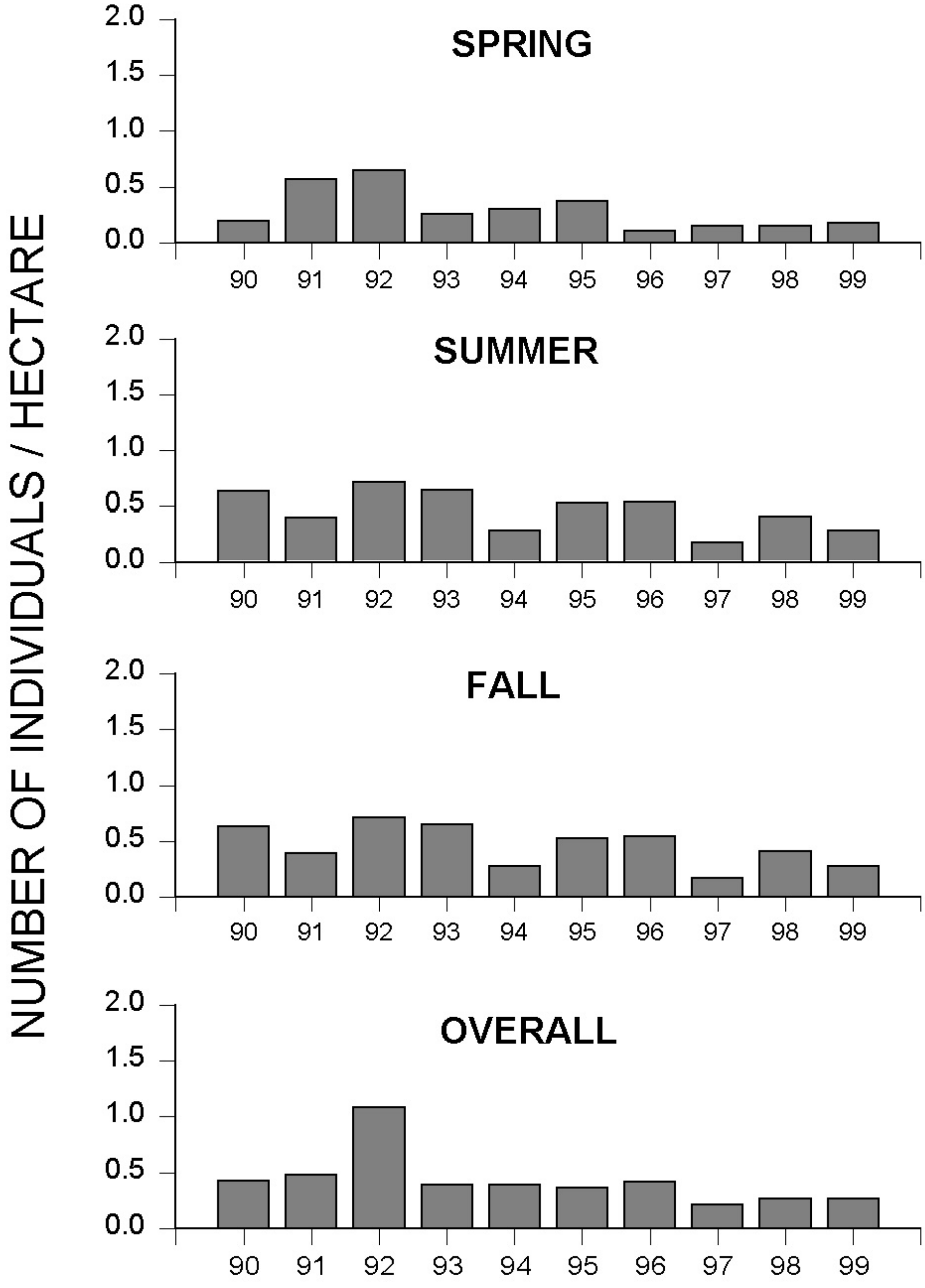



Figure 44. Annual densities of *Paralichthys dentatus* from inner strata

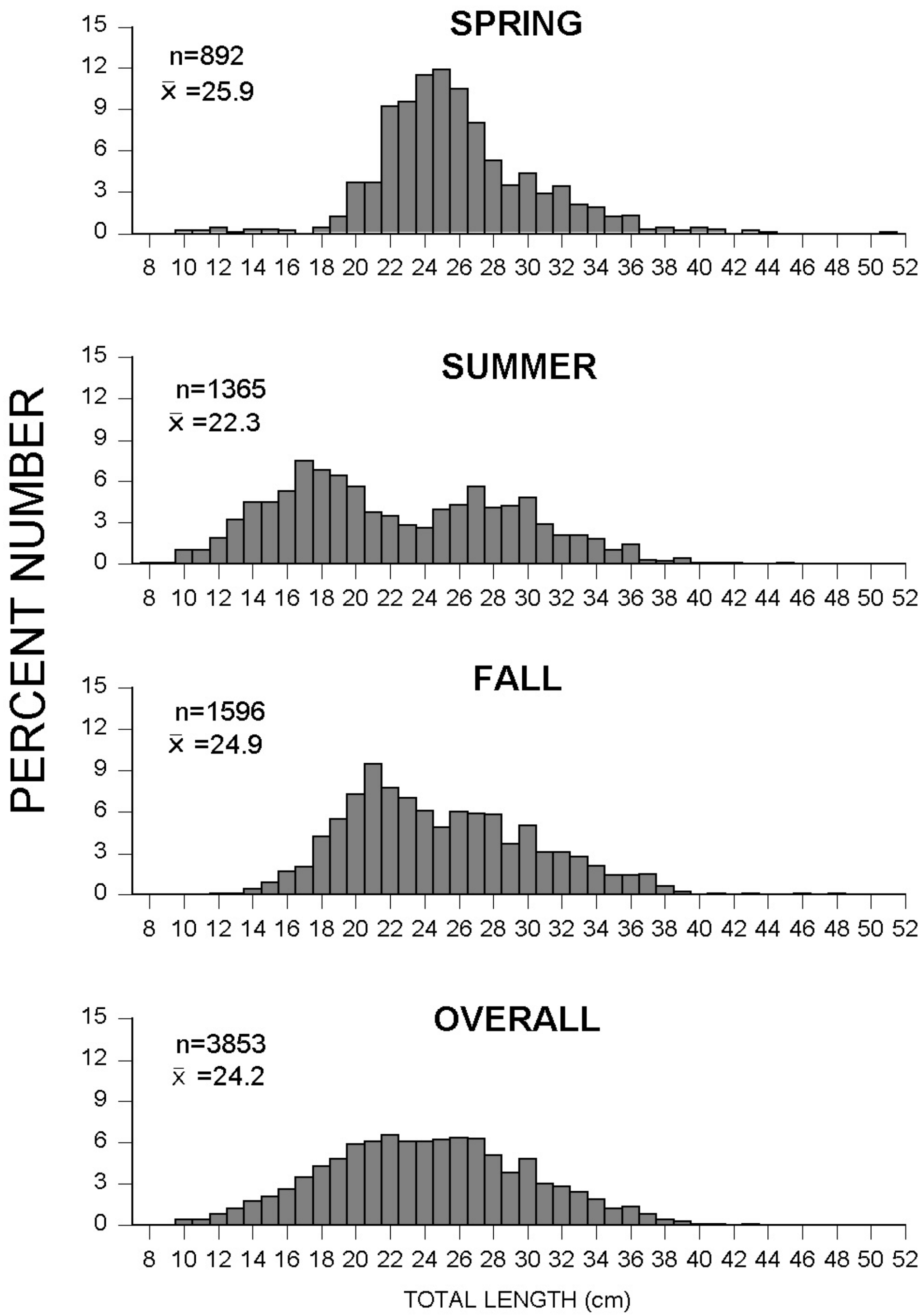



Figure 45. Seasonal length-frequencies of *Paralichthys dentatus* from inner strata 1990-1999.

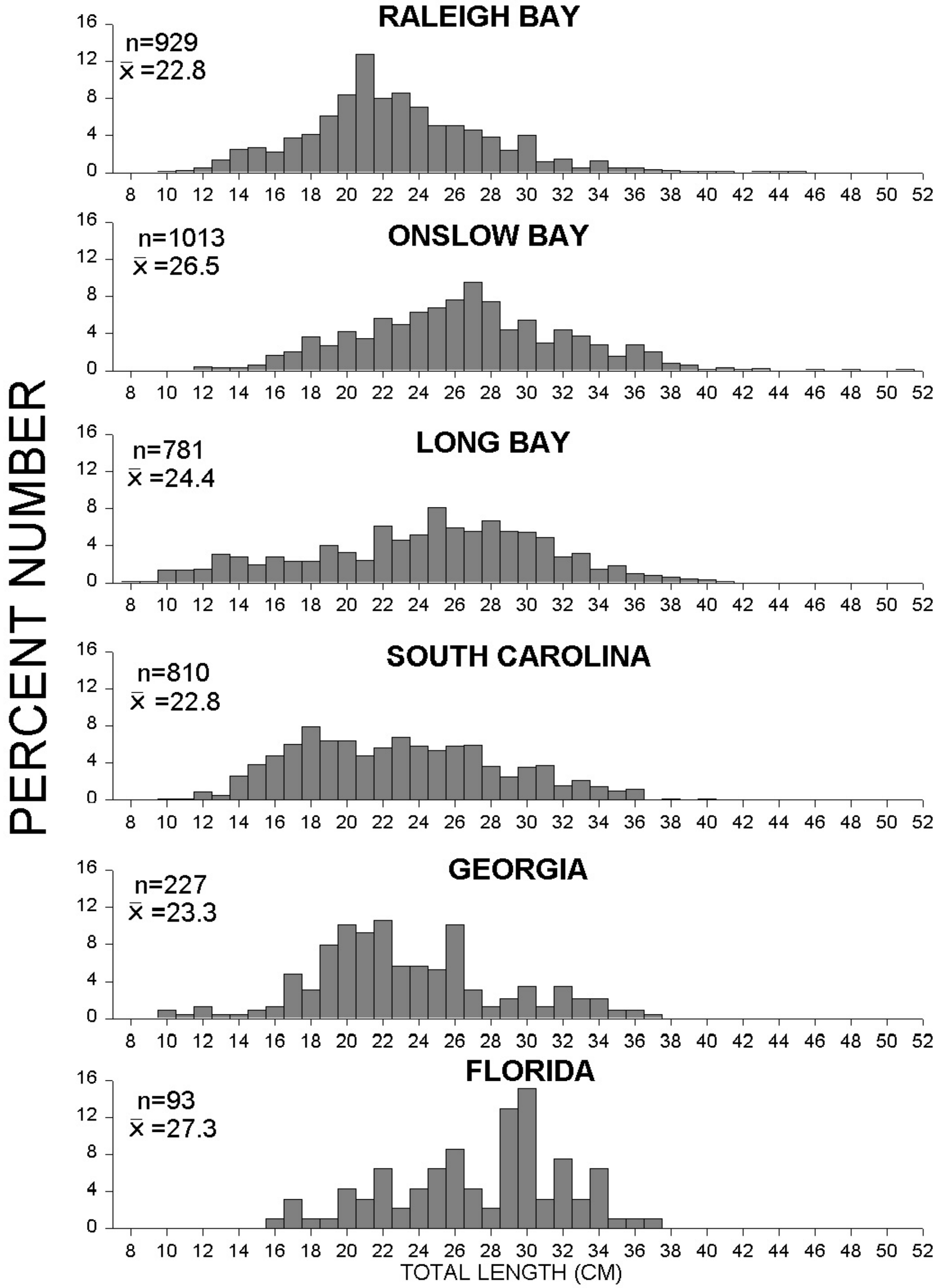



Figure 46. Regional length-frequencies of *Paralichthys dentatus* in inner strata 1990-1999.

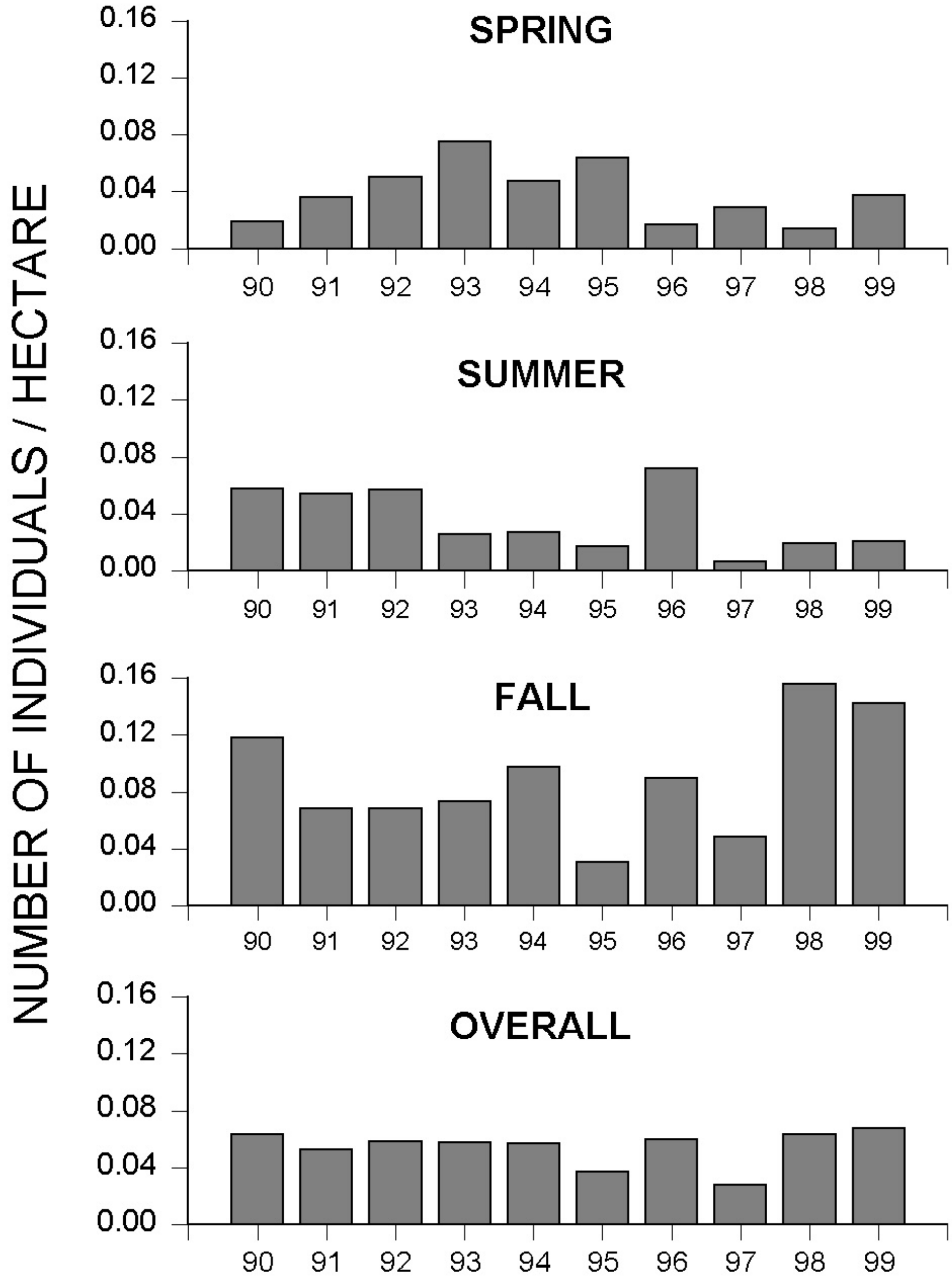



Figure 47. Annual densities of *Paralichthys lethostigma* from inner strata

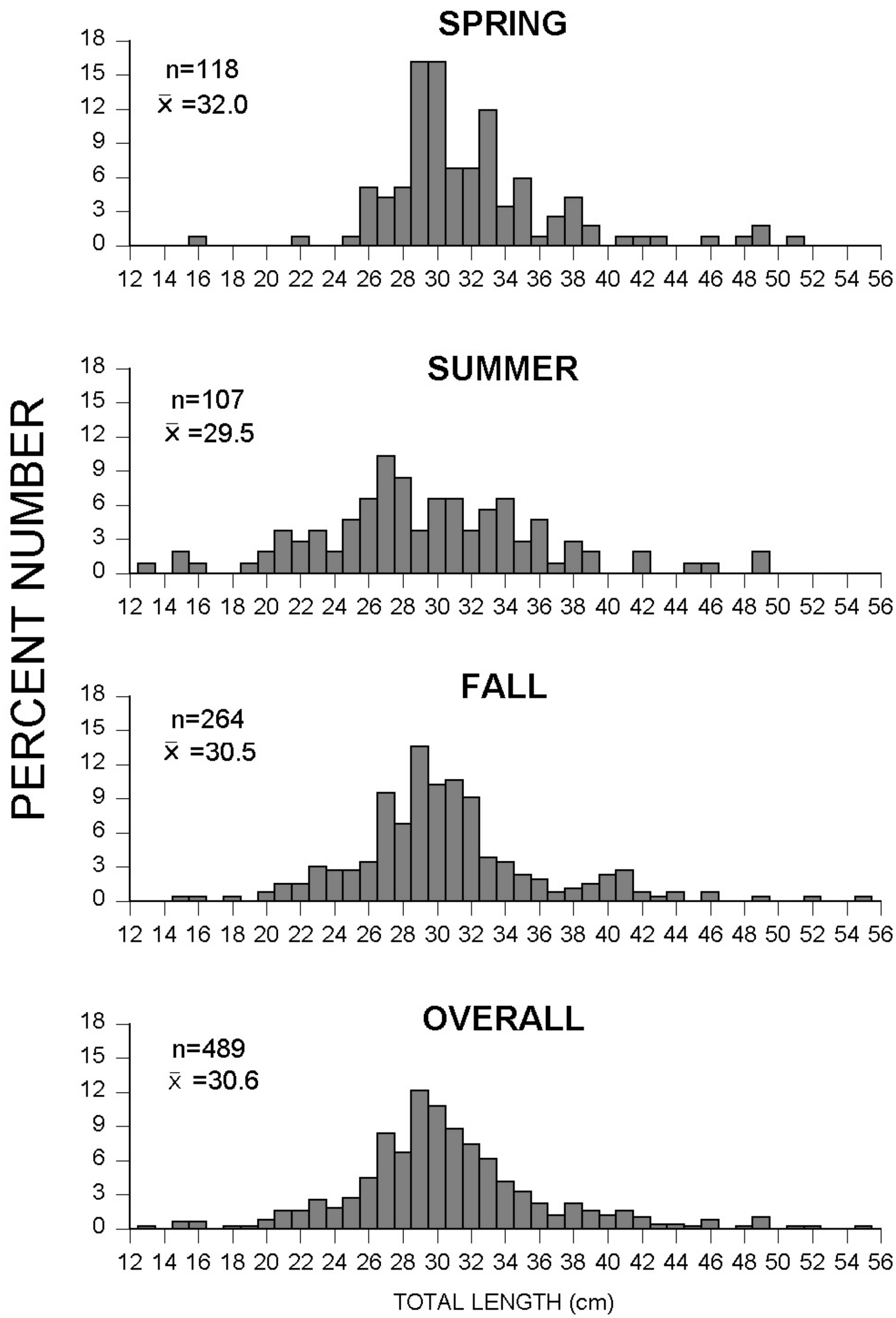



Figure 48. Seasonal length-frequencies of *Paralichthys lethostigma* from inner strata 1990-1999.

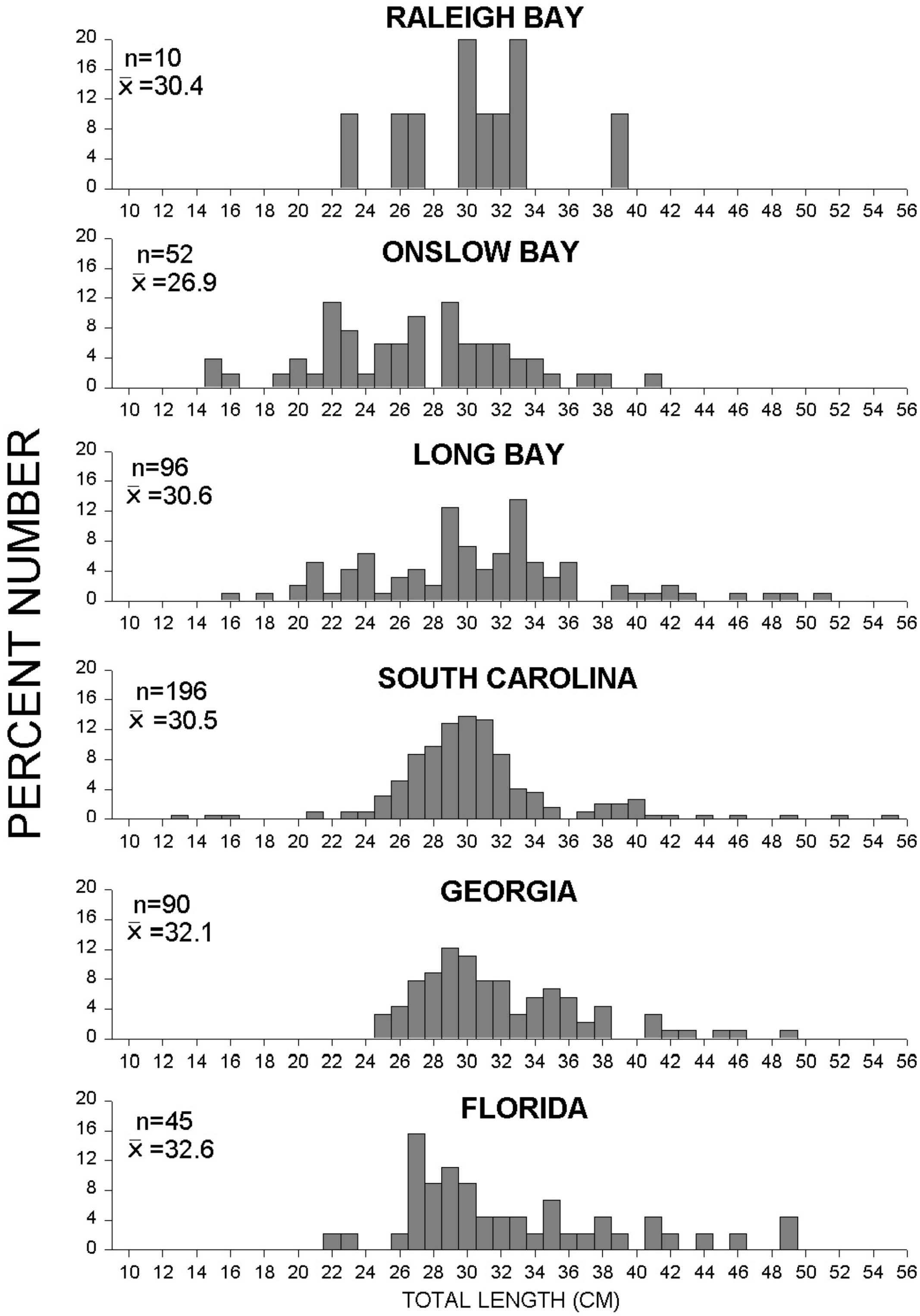



Figure 49. Regional length-frequencies of *Paralichthys lethostigma* in inner strata 1990-1999.

***Peprilus alepidotus***

The harvest fish occurs from the Chesapeake through the Gulf of Mexico and Caribbean Islands down to South America (Horn, 1970; Vergara, 1978). They are harvested as foodfish in North Carolina (Horn, 1970) and Florida (Vergara, 1978).

Inner strata yielded a total of 39,225 harvestfish (4.8 individuals/ha) weighing 1952 kg (0.2 kg/ha). Density of individuals peaked in 1991 and 1995 (Figure 50). Density was found to vary significantly among years ($X^2 = 27.6$, $p < 0.005$), seasons ($X^2 = 68.0$, $p < 0.0001$), and regions ($X^2 = 36.0$, $p < 0.0001$). Annual peaks in abundance reflect large catches of harvestfish in fall collections. Density was greatest in fall throughout the SAB (Table 7). Harvestfish were most abundant in the northern portion of the SAB, especially in Raleigh Bay, with occasional large catches in waters off Florida. Outer strata produced 1611 specimens (spring: n = 550, $\bar{X}$/ha = 0.51; fall: n = 1061, $\bar{X}$/ha = 1.79).

Total lengths of *Peprilus alepidotus* ranged from 1 to 21 cm ($\bar{X}$ = 10.3, n = 39,134). Length was significantly different among seasons ($X^2 = 774$, $p < 0.0001$). Mean length decreased from spring to fall, indicating the recruitment of YOY individuals (Figure 51). Mean length also varied significantly among regions ($X^2 = 55$, $p < 0.0001$), with larger fish occurring in Onslow Bay and off Georgia (Figure 52). The length-frequency distributions of harvestfish from all regions primarily comprise fish taken during fall cruises.

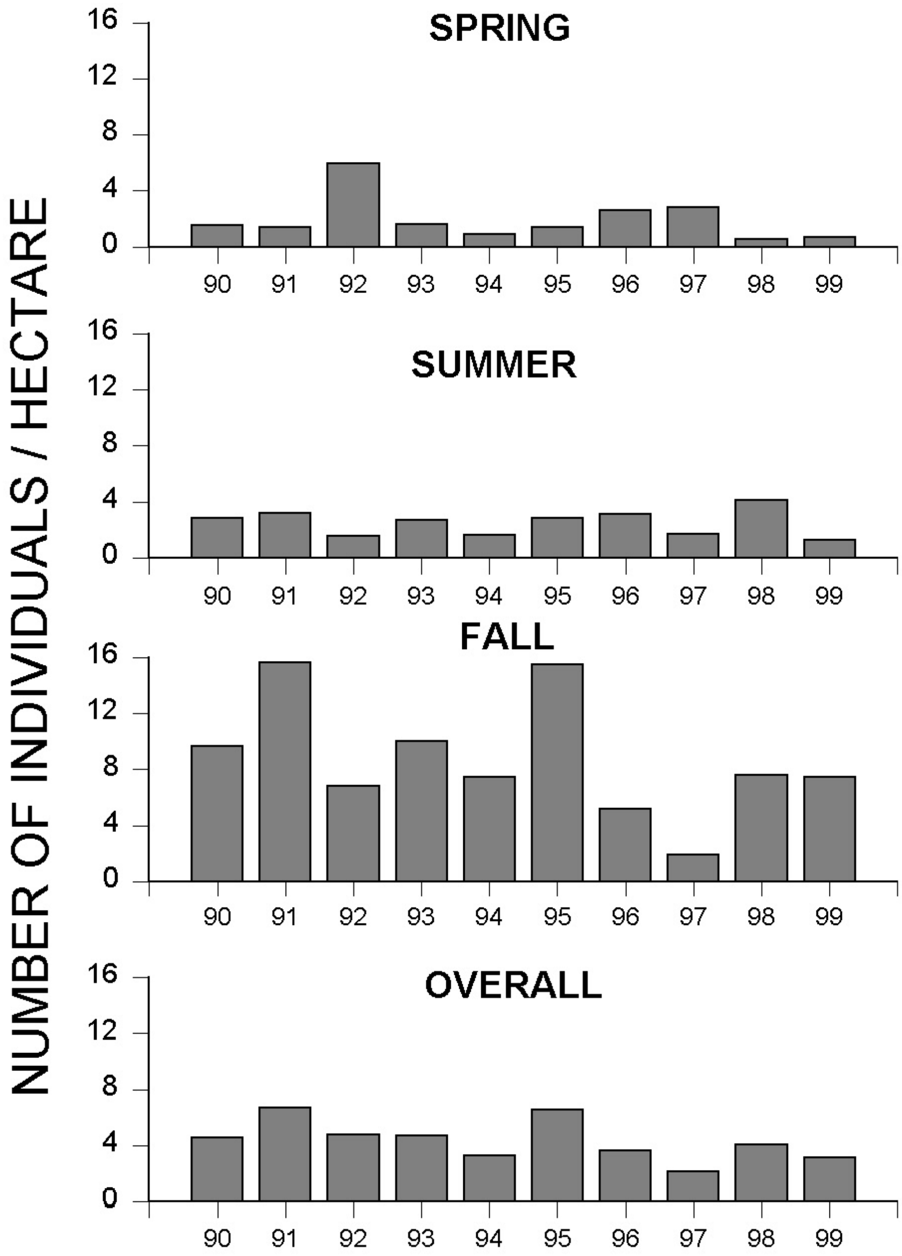



Figure 50. Annual densities of *Peprilus alepidotus* from inner strata

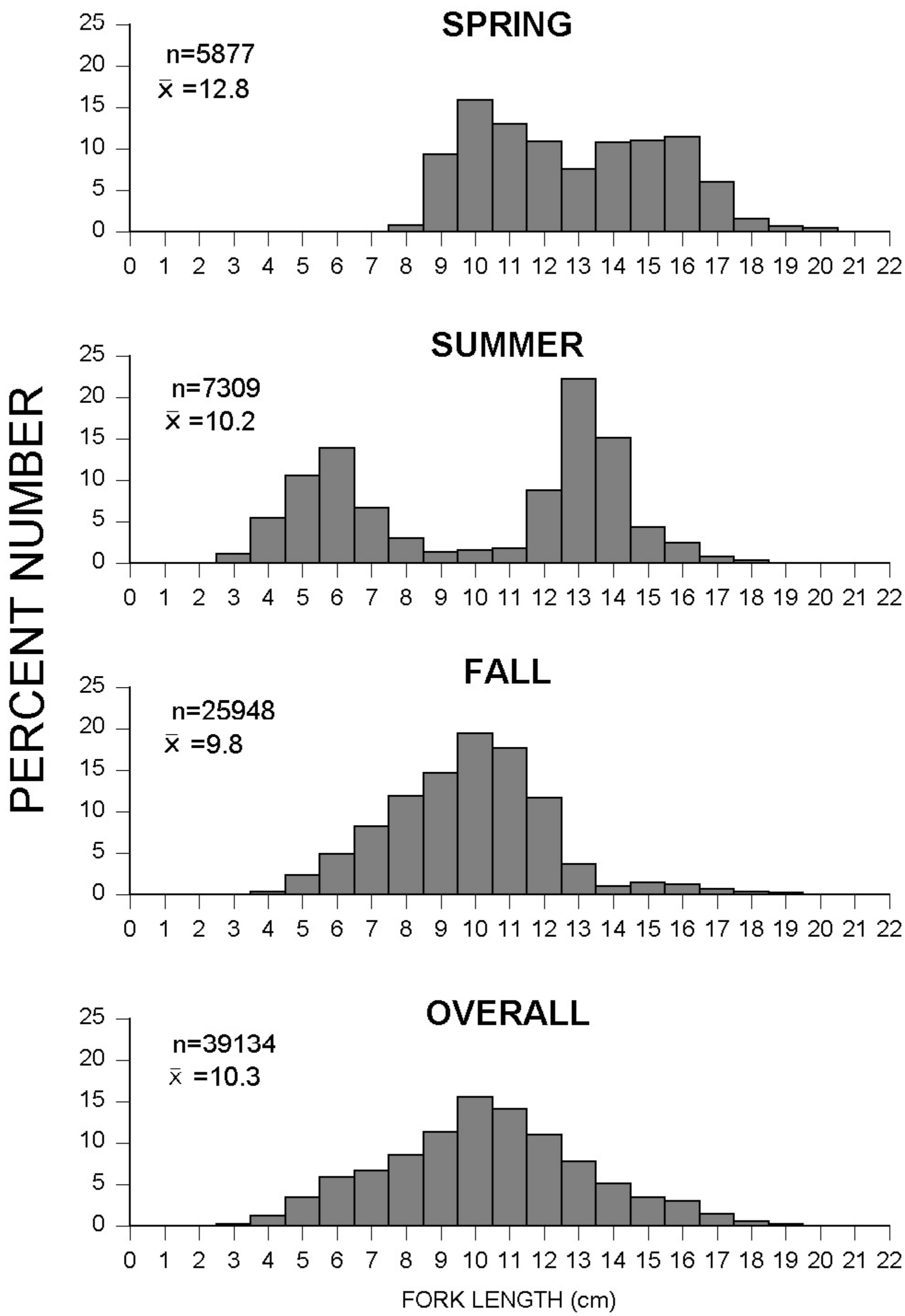



Figure 51. Seasonal length-frequencies of *Peprilus alepidotus* from inner strata 1990-1999.

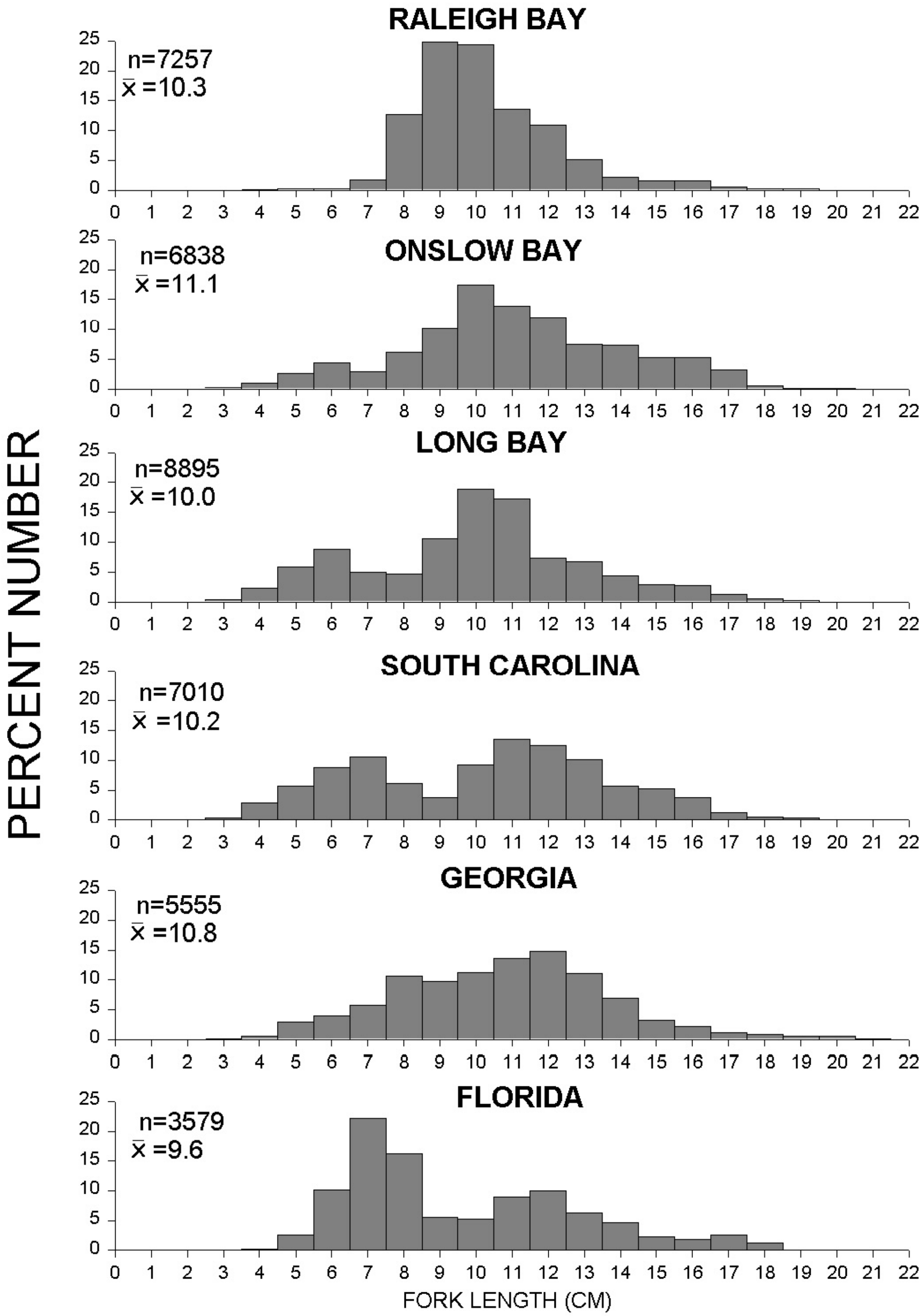



Figure 52. Regional length-frequencies of *Peprilus alepidotus* in inner strata 1990-1999.

### *Peprilus triacanthus*

The butterfish ranges from Nova Scotia throughout the Gulf of Mexico to the Yucatan Peninsula (Vergara, 1978). Generally found in waters less than 55 m (Vergara. 1978), this schooling pelagic species migrates to offshore waters in the colder months (Horn, 1970). The young tend to be associated with floating plants and debris, and jellyfish. They are taken commercially and marketed as a food fish.

Inner strata yielded a total of 35,383 butterfish (4.6 individuals/ha) weighing 925 kg (0.1 kg/ha). Density of individuals was at the highest level in the history of the SEAMAP-SA project in 1996 and 1998 (Figure 53). Density was found to vary significantly among years ($X^2 = 58.3$, $p < 0.0001$), seasons ($X^2 = 75.7$, $p < 0.0001$), and regions ($X^2 = 74.7$, $p < 0.0001$). Density was greatest in spring and more than 32% of all butterfish taken in inner strata were collected in Raleigh Bay (Table 7). In inner strata in Raleigh Bay, butterfish ranked 5th in abundance overall. Butterfish were generally most abundant in the northern portion of the SAB, with density decreasing with decreasing latitude. Outer strata produced 9974 specimens (spring: n = 6036, $\bar{X}$/ha = 5.60; fall: n = 3938, $\bar{X}$/ha = 6.65).

Total lengths of *Peprilus triacanthus* ranged from 1 to 21 cm ($\bar{X} = 9.4$, n = 35,315). Length was significantly different among seasons ($X^2 = 435$, $p < 0.0001$). Mean length increased from spring to summer (Figure 54). Mean length also varied significantly among regions ($X^2 = 412$, $p < 0.0001$), with larger fish occurring in Raleigh Bay and off Florida (Figure 55). The length-frequency distribution of butterfish in Raleigh Bay represents approximately 33% of all butterfish taken from inner strata, with most of the smaller fish collected in spring and a greater percentage of larger fish in fall collections. Only 6% of the butterfish from Raleigh Bay were caught in summer. Mean lengths of butterfish were greatest in collections from Raleigh Bay, Onslow Bay, and waters off Florida.

### *Pogonias cromis*

Black drum extend along the western Atlantic coast from the Gulf of Maine to South Florida and the Lesser Antilles to Guyana, and from Guyana to Rio Grande, Brazil (Chao, 1978). They occur in the Gulf of Mexico from South Florida to a little south of Brownsville Texas along the Mexican coast, and also along the Caribbean side of Cuba. Black Drum is a bottom feeding species found over sand and sandy mud bottoms that is abundant along beaches and large river runoffs. Juveniles can be found in estuaries.

The black drum, *Pogonias cromis*, was a rare species in SEAMAP-SA collections. Only 60 individuals were collected during ten years of the survey. All of the black drum collected were taken in inner strata in fall, with the exception of 2 individuals taken in spring (Table 7). Most black drum were caught in the southern portion of the SAB. Density of abundance was greatest off Georgia and Florida. Total length of black drum ranged from 15 to 115 cm ($\bar{X} = 24.5$).

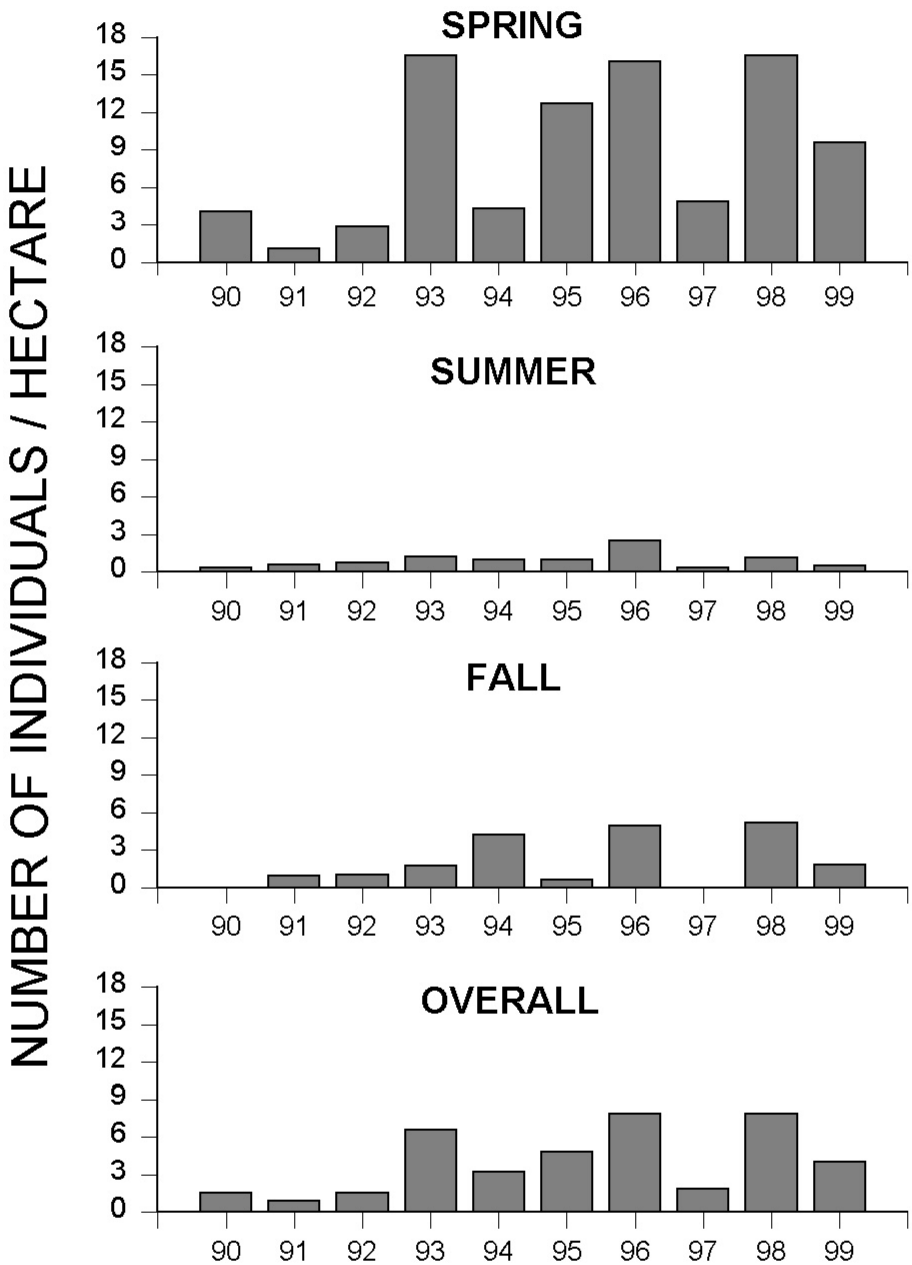



Figure 53. Annual densities of *Peprilus triacanthus* from inner strata

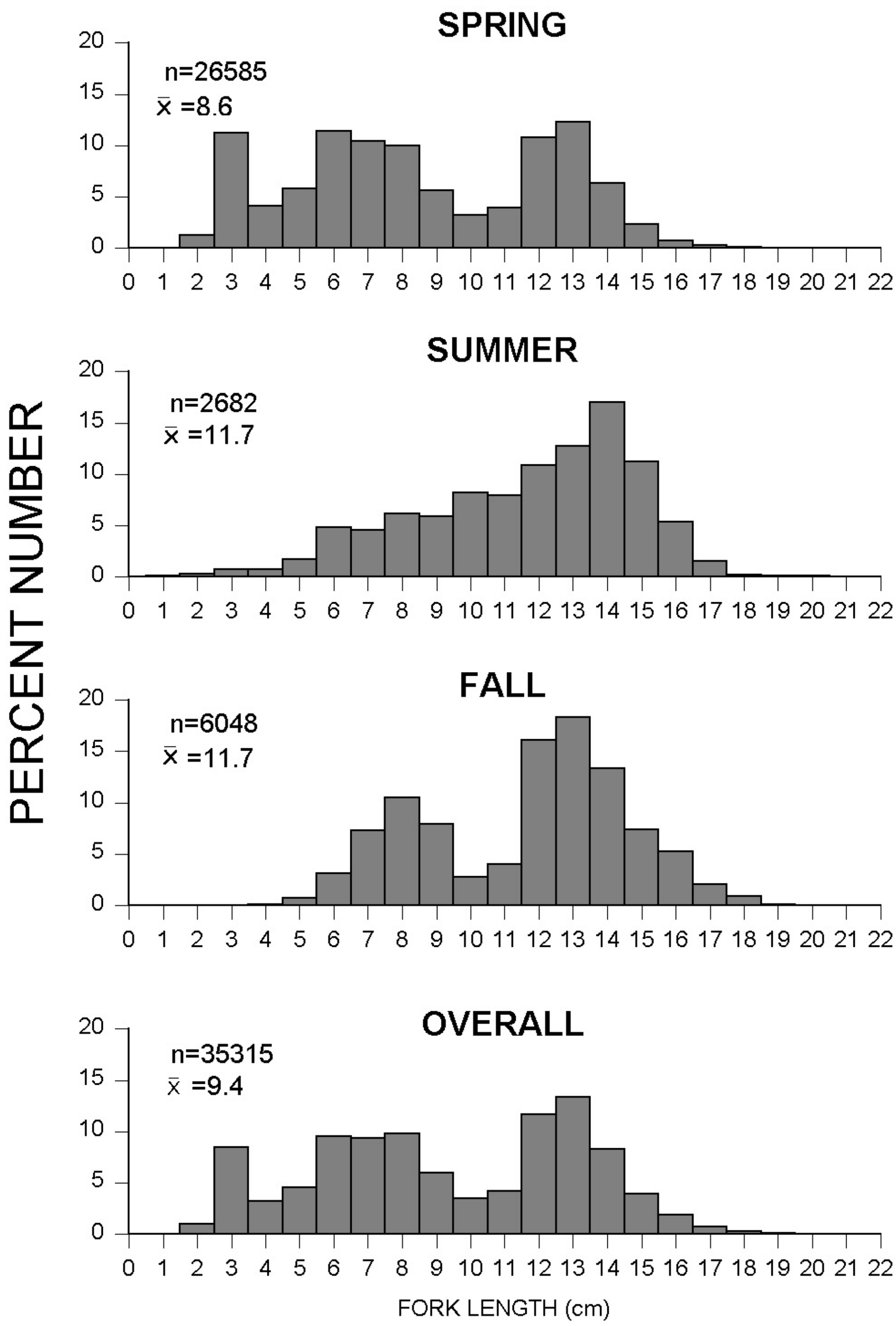



Figure 54. Seasonal length-frequencies of *Peprilus triacanthus* from inner strata 1990-1999.

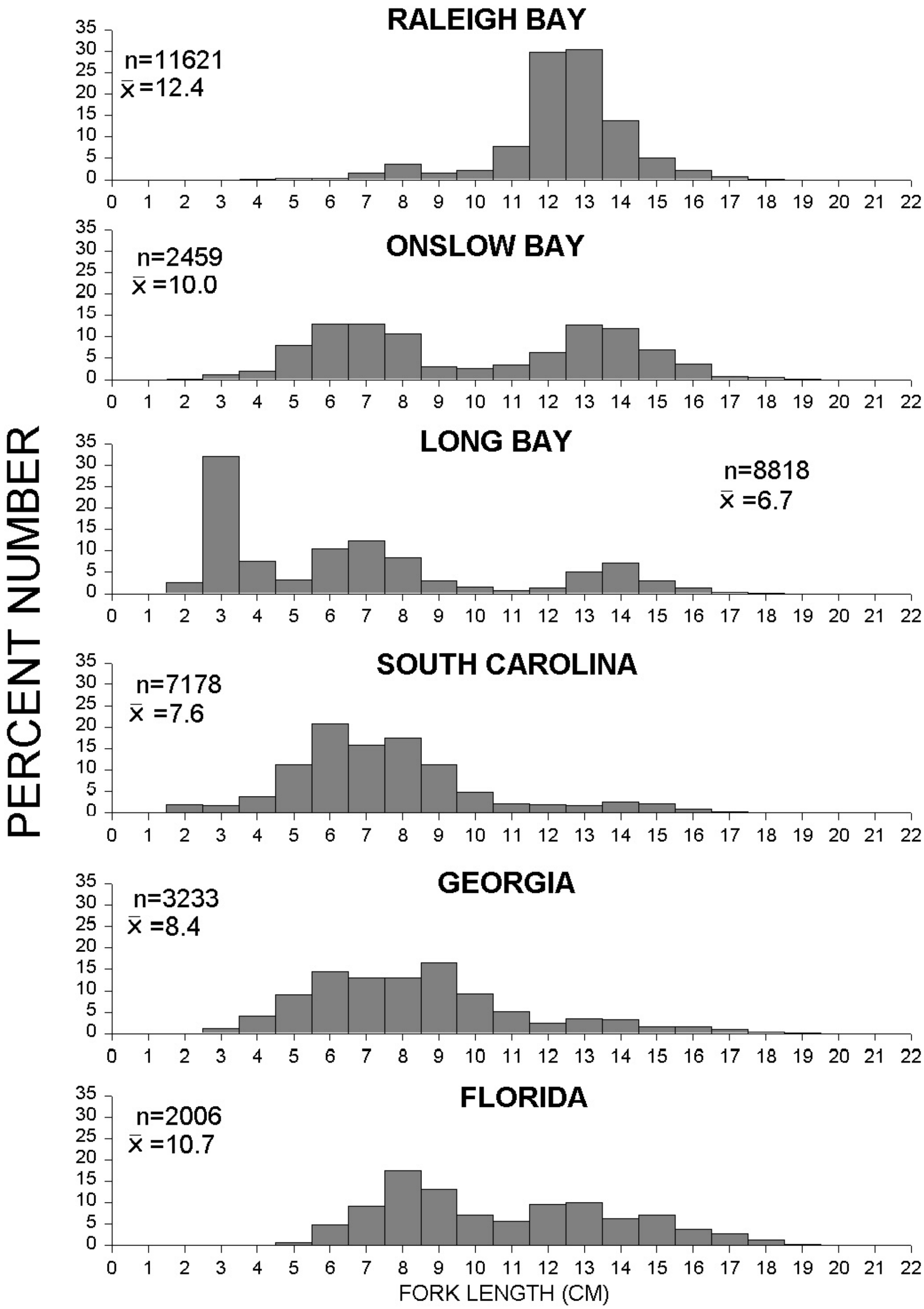



Figure 55. Regional length-frequencies of *Peprilus triacanthus* in inner strata 1990-1999.

### *Pomatomus saltatrix*

The bluefish is a schooling pelagic fish found in the eastern Atlantic from Nova Scotia throughout the Gulf of Mexico including northern Cuba, along the South American coast from Colombia to Argentina. It also occurs in the eastern Atlantic, the Mediterranean and the Indo-west Pacific (Collette 1978). Bluefish are important for recreation and food and are the target of a large commercial fishery.

Inner strata yielded a total of 12,161 bluefish (1.5 individuals/ha) weighing 1185 kg (0.1 kg/ha). Density of individuals varied significantly among years ($X^2 = 33.2$, $p < 0.005$), seasons ($X^2 = 75.5$, $p < 0.0001$), and regions ($X^2 = 117.5$, $p < 0.0001$). Density was found to be at the highest level in the history of the SEAMAP-SA project in 1995 (Figure 56). Density was greatest in spring (Table 7). Bluefish were most abundant in the northern portion of the SAB, with density of individuals decreasing with decreasing latitude. Outer strata produced 199 specimens (spring: n = 140, $\bar{X}$/ha = 0.13; fall: n = 59, $\bar{X}$/ha = 0.10).

Total lengths of *Pomatomus saltatrix* ranged from 6 to 39 cm ($\bar{X} = 19.2$, n = 12,150). Length was significantly different among seasons ($X^2 = 235$, $p < 0.0001$). Mean length increased from spring to fall, an indication of result of juvenile growth (Figure 57). Mean length also varied significantly among regions ($X^2 = 170$, $p < 0.0001$), with larger fish occurring in the southern portion of the SAB (Figure 58). The length-frequency distributions of bluefish from South Carolina northward comprise primarily individuals taken in spring collections, when most of the smaller fish were taken. Smaller individuals from waters off Georgia and Florida were taken in fall collections, as were the larger individuals. Mean lengths of bluefish were greatest in collections from waters off South Carolina, Georgia, and Florida.

### *Sciaenops ocellatus*

Red drum are found along the western Atlantic coast from New York to Florida and in the Gulf of Mexico from South Florida to Laguna Madre, with a distinct population suspected to be living in the Indian River (Chao, 1978). Red drum are found over sand and mud bottoms in coastal waters where it is abundant in estuaries and the surf zone, but can also be found feeding and sheltering in the salt marsh grass at high tide.

The red drum was a very rare species in SEAMAP-SA trawls. Only 4 individuals, 3 of which were collected in inner strata, were taken, all in Long Bay and off South Carolina (Table 7). No red drum were taken during summer cruises. Lengths ranged from 85 to 108 cm ($\bar{X} = 96.0$).

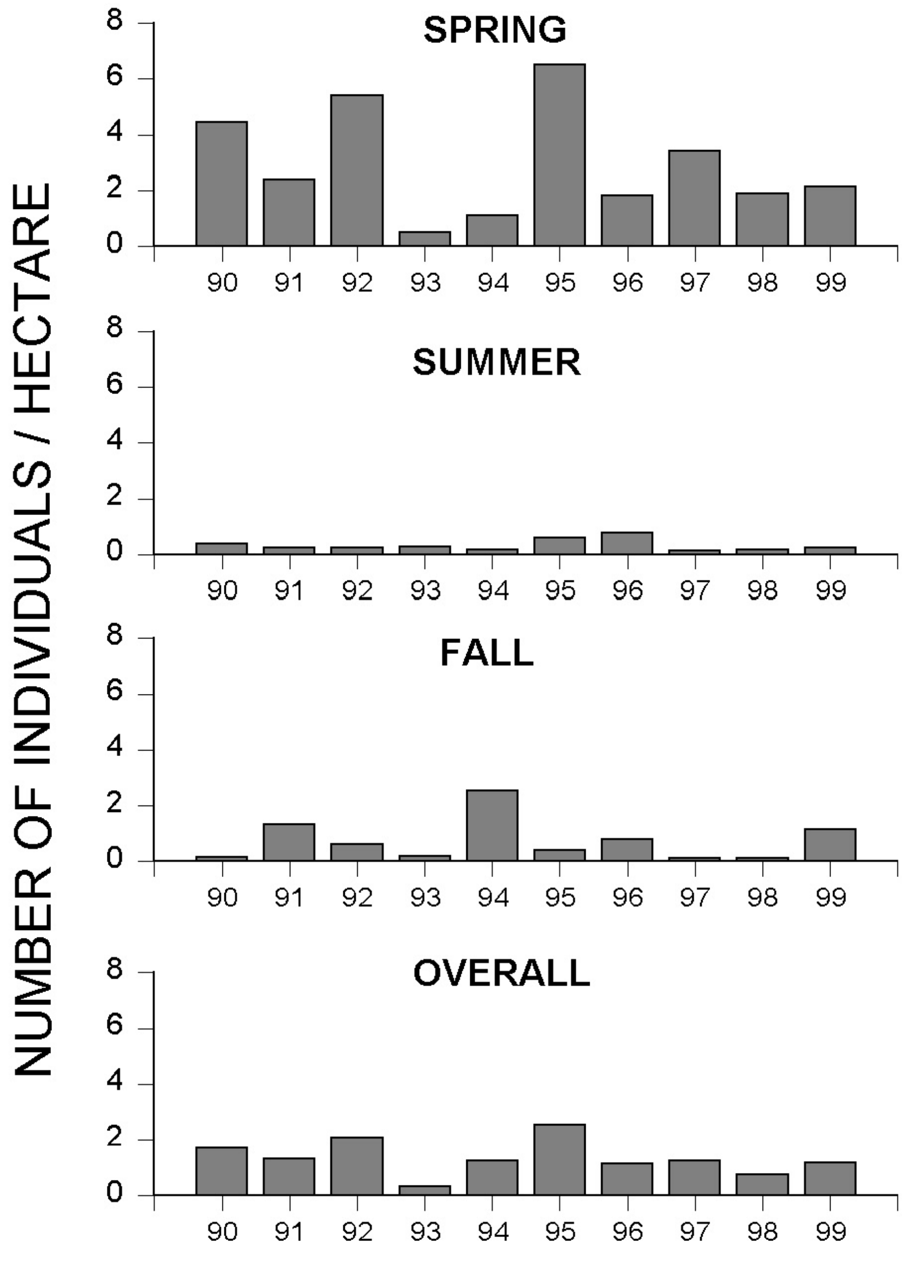



Figure 56. Annual densities of *Pomatomus saltatrix* from inner strata

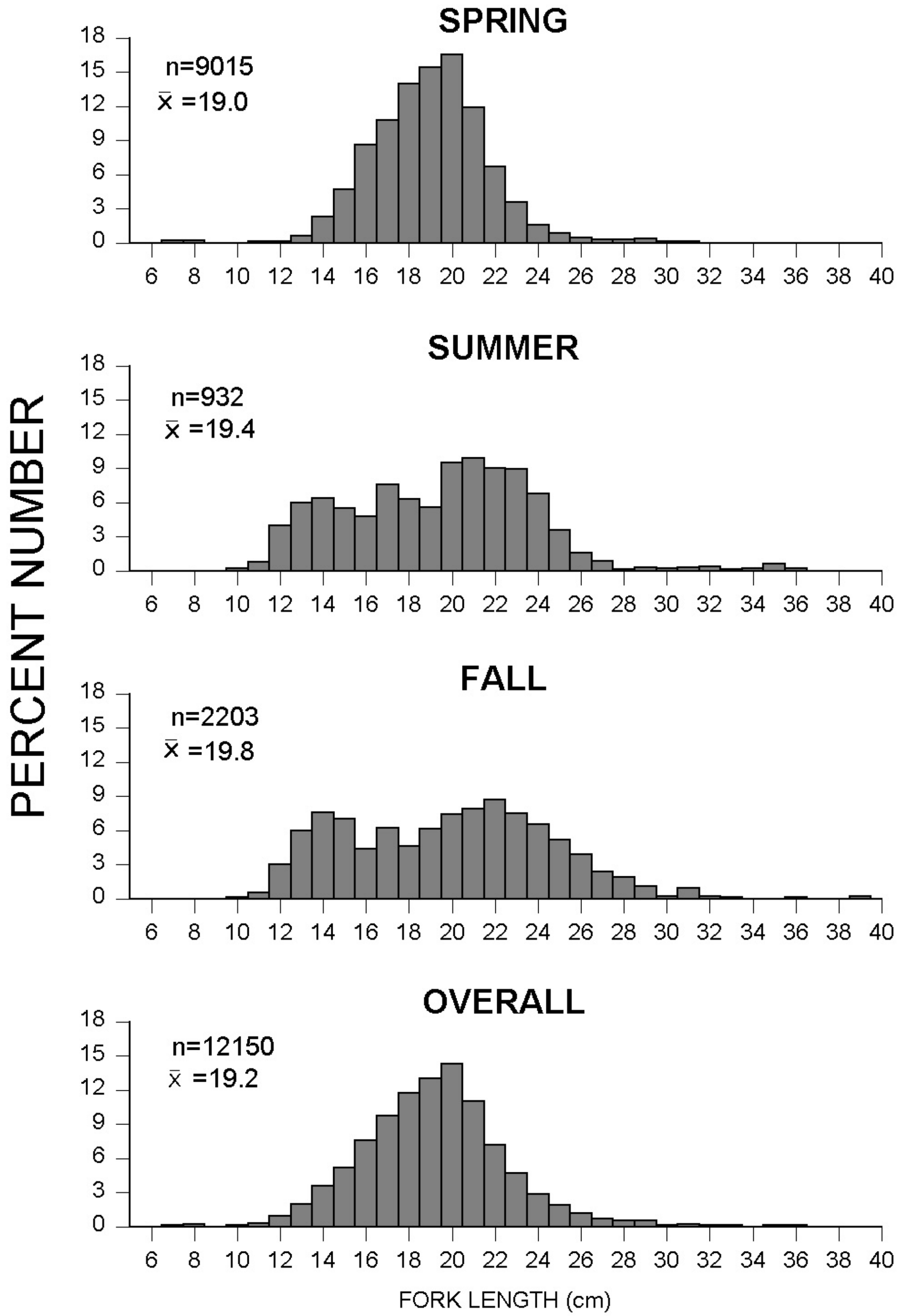



Figure 57. Seasonal length-frequencies of *Pomatomus saltatrix* in inner strata 1990-1999.

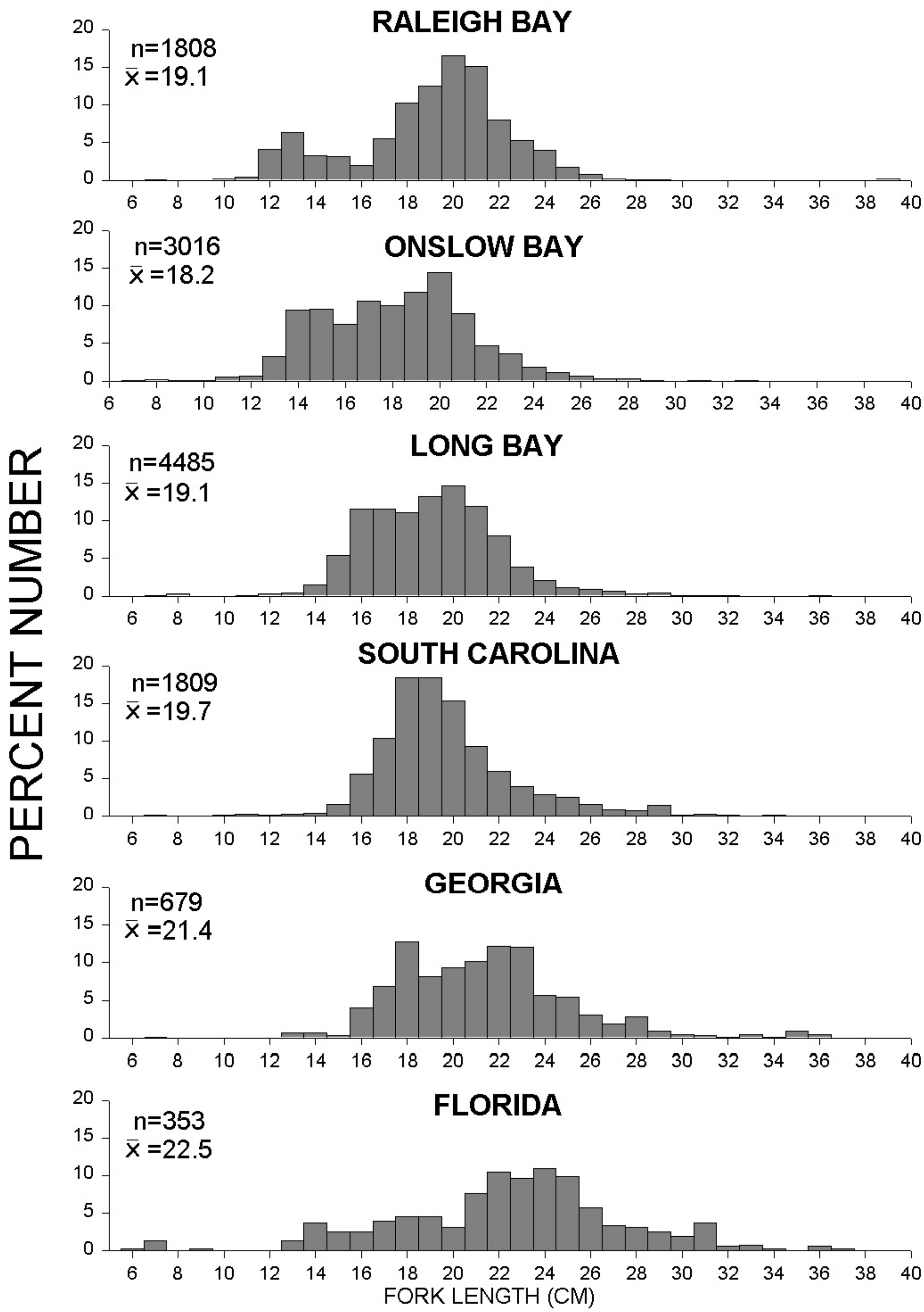



Figure 58. Regional length-frequencies of *Pomatomus saltatrix* in inner strata 1990-1999.

## *Scomberomorus cavalla*

The king mackerel inhabits Atlantic coastal waters from Massachusetts south throughout the Gulf of Mexico and the Caribbean to Rio de Janeiro (Collette, 1978), possibly extending as far north as Maine (Fritzsche, 1978; Berrien and Finan, 1977). Atlantic stocks of king mackerel migrate northward from Florida during the warmer spring and summer months and return south as the waters get colder (Berrien and Finan, 1977), occurring singly or in small groups (Collette, 1978). Commercially, this species is the target of large purse-seine, gill-net, and hook-and-line fisheries (Collette, 1978). King mackerel spawn from May through September, with a peak in spawning activity in July (Finucane et al., 1986).

The 6604 (0.8 individuals/ha) king mackerel collected from inner strata during ten years of the survey weighed 416 kg (0.05 kg/ha). The density of king mackerel peaked in 1996 and again in 1998 (Figure 59). Density was found to vary significantly among years ($X^2 = 59.9$, $p < 0.0001$), seasons ($X^2 = 38.3$, $p < 0.0001$), and regions ($X^2 = 24.0$, $p < 0.0002$). Density was greatest in fall (Table 7). Approximately 37% of all king mackerel from inner strata were collected off Florida. Outer strata produced 573 king mackerel (spring: n = 301, $\bar{X}$/ha = 0.28; fall: n = 272, $\bar{X}$/ha = 0.46).

Fork lengths of *Scomberomorus cavalla* ranged from 4 to 117 cm ($\bar{X}$ = 15.8 cm, n = 6603) and represented two year-classes. Annual cohorts of king mackerel are spawned in spring and summer (Finucane et al., 1986) and reach mean lengths greater than 40 cm by the end of their first year (Collins et al., 1989). Lengths were significantly different among seasons ($X^2 = 951$, $p < 0.0001$) and mean length decreased from spring to fall (Figure 60). The fish less than 15 cm and greater than 34 cm in summer suggest that recruitment is beginning and that a few specimens from the Age II year class are still present. Lengths varied significantly among regions ($X^2 = 181$, $p < 0.0001$), with Florida waters producing the greatest mean length and mean size decreasing northward (Figure 61).

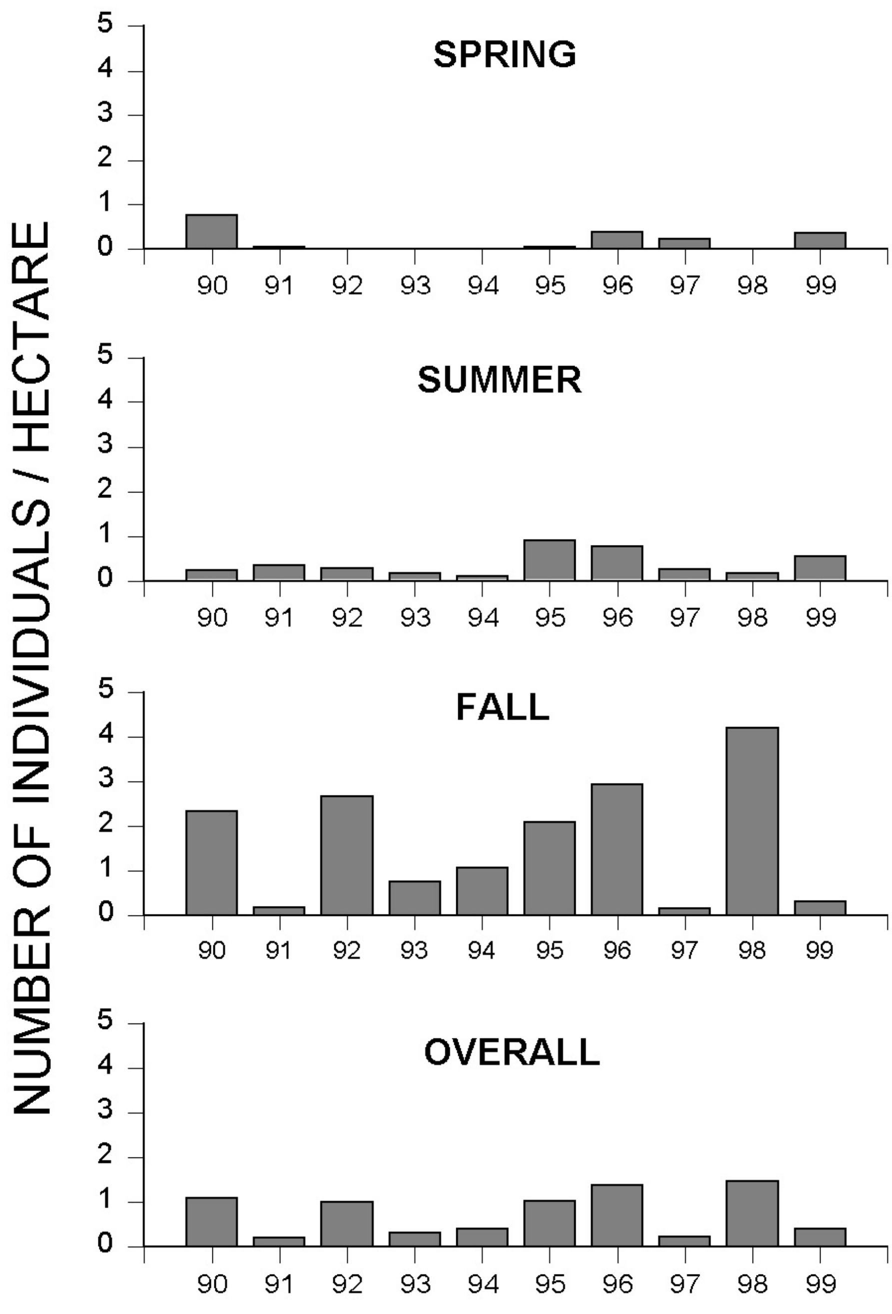



Figure 59. Annual densities of *Scomberomorus cavalla* from inner strata

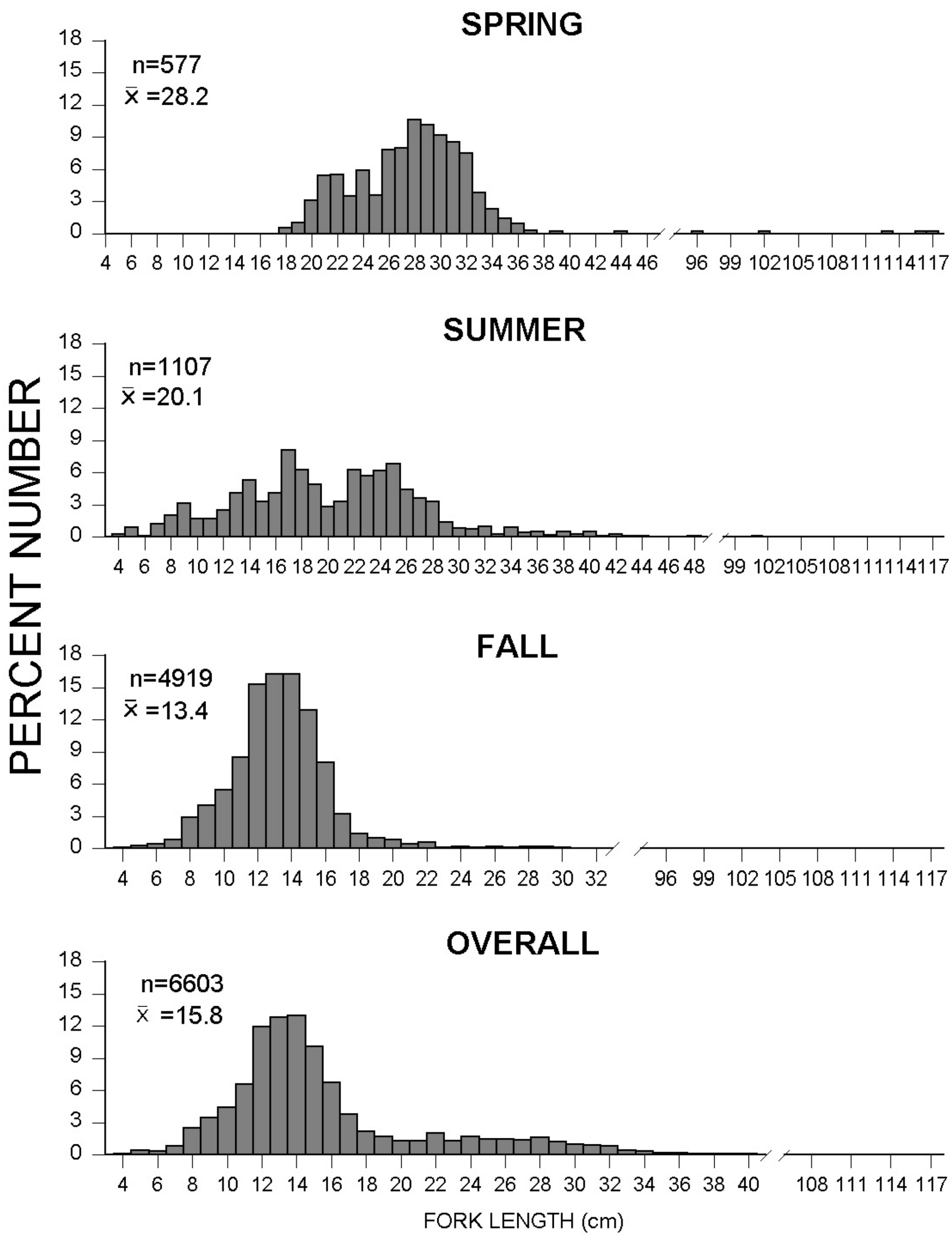



Figure 60. Seasonal length-frequencies of *Scomberomorus cavalla* in inner strata 1990-1999.

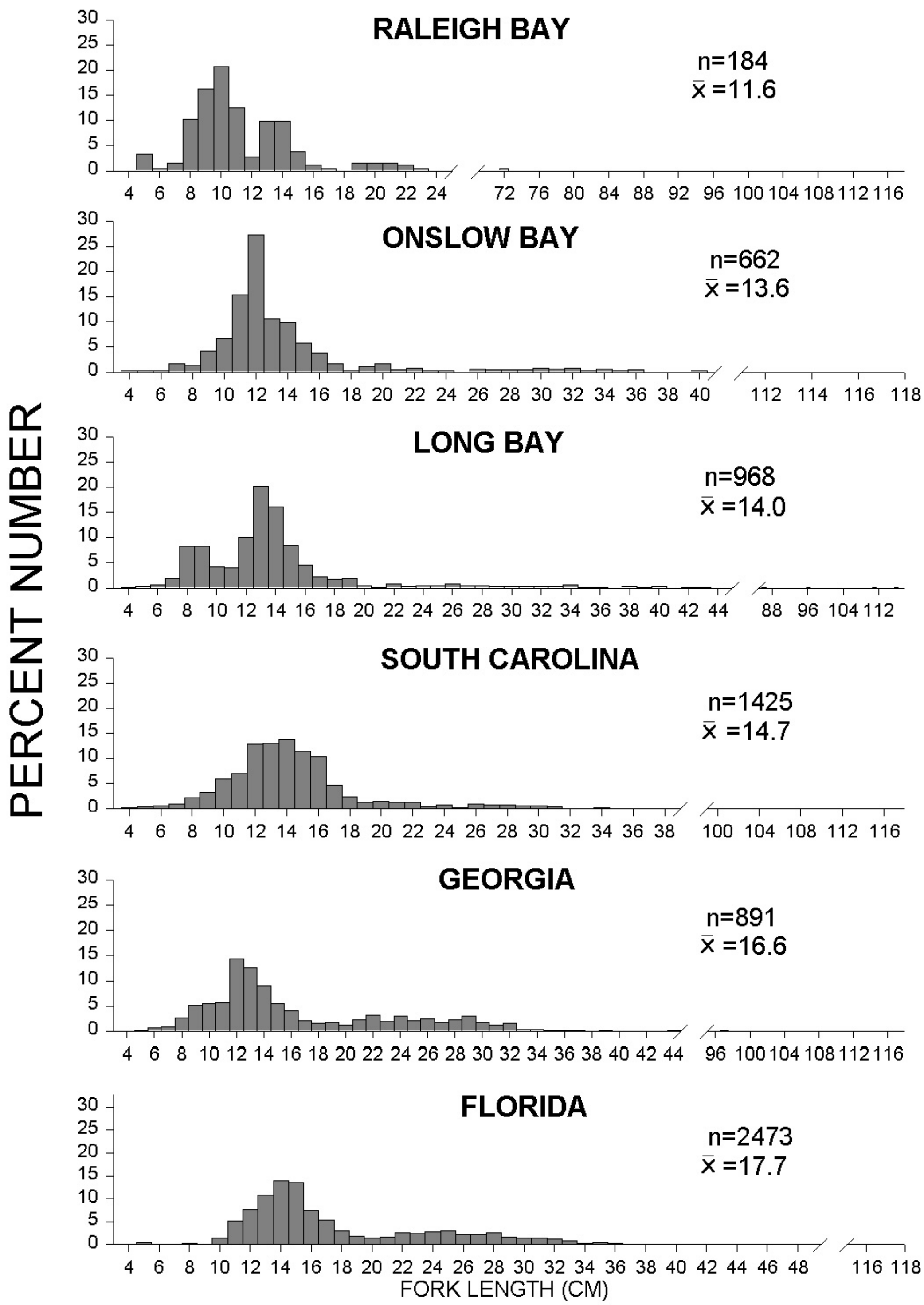



Figure 61. Regional length-frequencies of *Scomberomorus cavalla* in inner strata 1990-1999.

***Scomberomorus maculatus***

Spanish mackerel range from the Gulf of Maine to the Yucatan Peninsula, where they are replaced by *Scomberomorus brasiliensis* from Belize to Brazil (Collette and Russo, 1984). Generally occurring in coastal waters at depths of less than 72 m, S. *maculatus* are known to enter estuaries occasionally (Fritzsche, 1978). An excellent food fish, this species is the target of recreational anglers and supports a large purse-seine and gill-net fishery (Fritzsche, 1978).

Sampling in 1990-1999 produced 12,762 Spanish mackerel that weighed a total of 1441 kg (1.5 individuals/ha; 0.2 kg/ha). The density of individuals of Spanish mackerel peaked in 1990-1992 (Figure 62). Density varied significantly among years ($X^2 = 29.5$, $p < 0.0005$) and seasons ($X^2 = 11.7$, $p < 0.005$), but not among regions ($X^2 = 1.0$, $p > 0.9$). The highest density of Spanish mackerel was found in the southern SAB, off Georgia and Florida. (Table 7). Outer strata produced 540 Spanish mackerel, 82% of which were collected in spring in the southern SAB (spring: n = 443, $\bar{X}$/ha = 0.41; fall: n = 97, $\bar{X}$/ha = 0.16).

Fork lengths of Spanish mackerel ranged from 2 to 58 cm ($\bar{X}$ = 21.4 cm, n = 12,762). Lengths differed significantly among seasons ($X^2 = 1830$, $p < 0.0001$). Mean length decreased from spring to summer, indicating the recruitment of YOY individuals, and increased in fall as the result of subsequent juvenile growth (Figure 63). By the end of their first year, Spanish mackerel reach lengths greater than 30 cm (Powell, 1975). Specimens collected in spring were generally fish ending their first year. Summer collections contained primarily newly recruited YOY with a few representatives of the previous year-class still present. Fall collections were made up of fish from two year-classes. Length also varied significantly among regions ($X^2 = 115$, $p < 0.0001$), and mean lengths ranged from a low of 19.0 cm in Onslow Bay to 23.6 cm off Georgia (Figure 64).

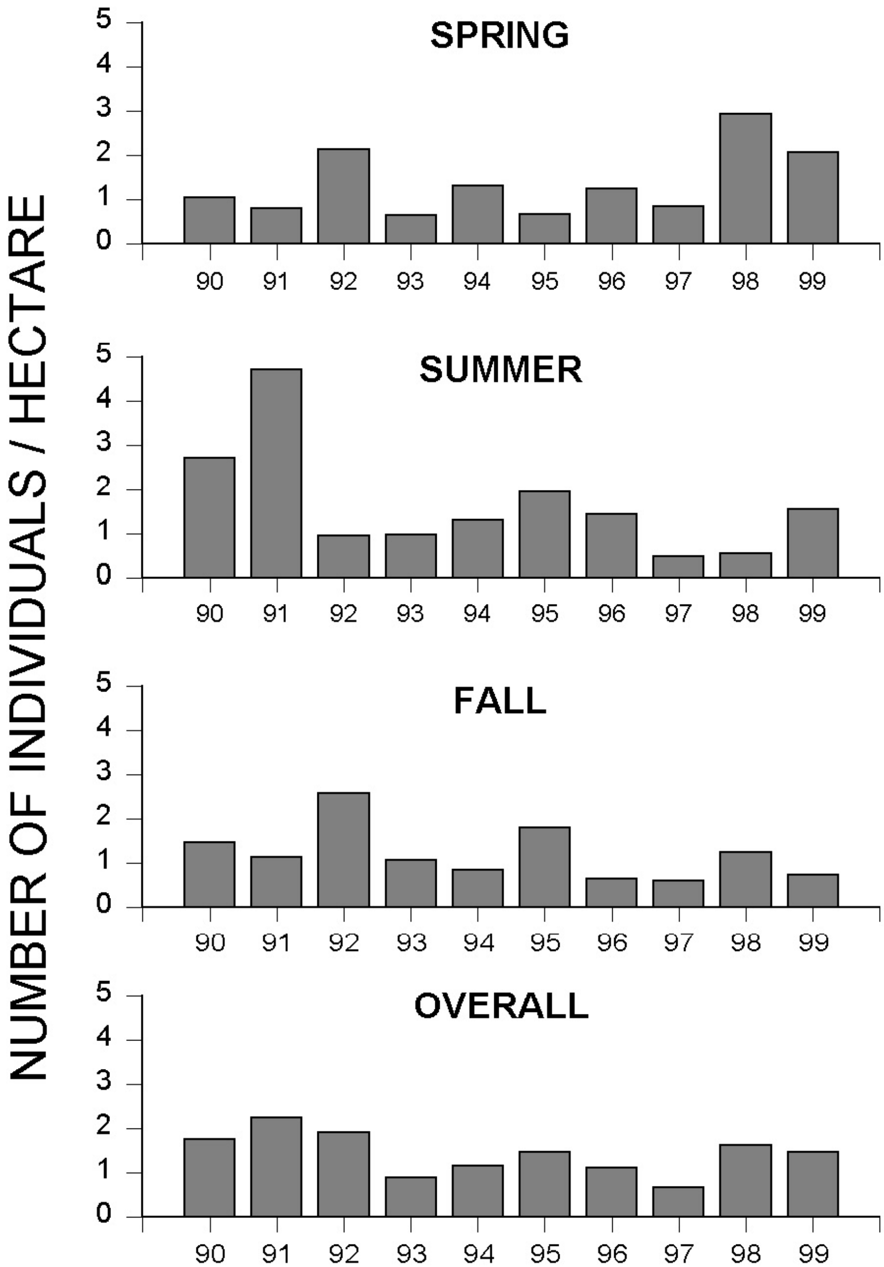



Figure 62. Annual densities of *Scomberomorus maculatus* from inner strata

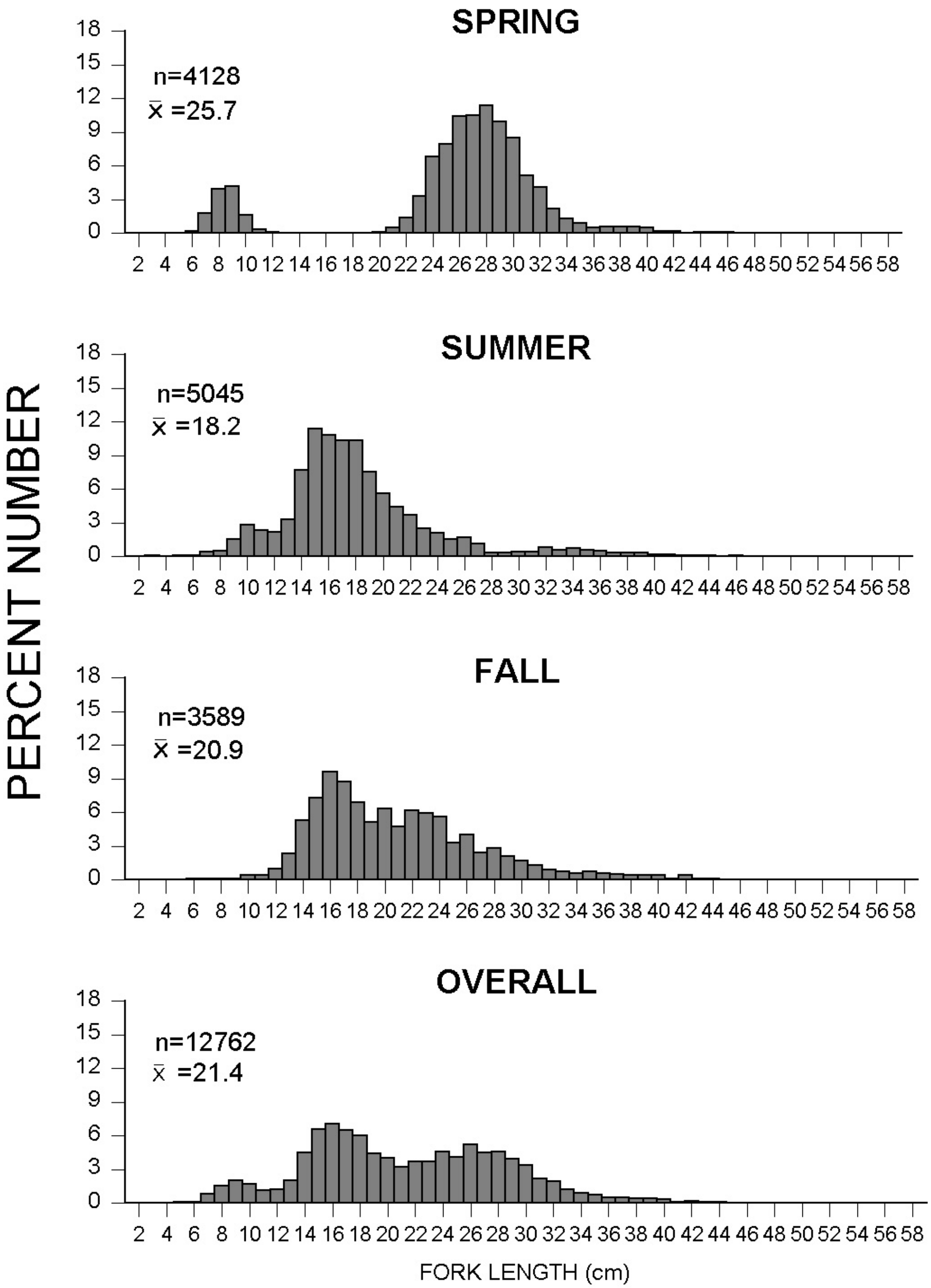



Figure 63. Seasonal length-frequencies of *Scomberomorus maculatus* in inner strata 1990-1999.

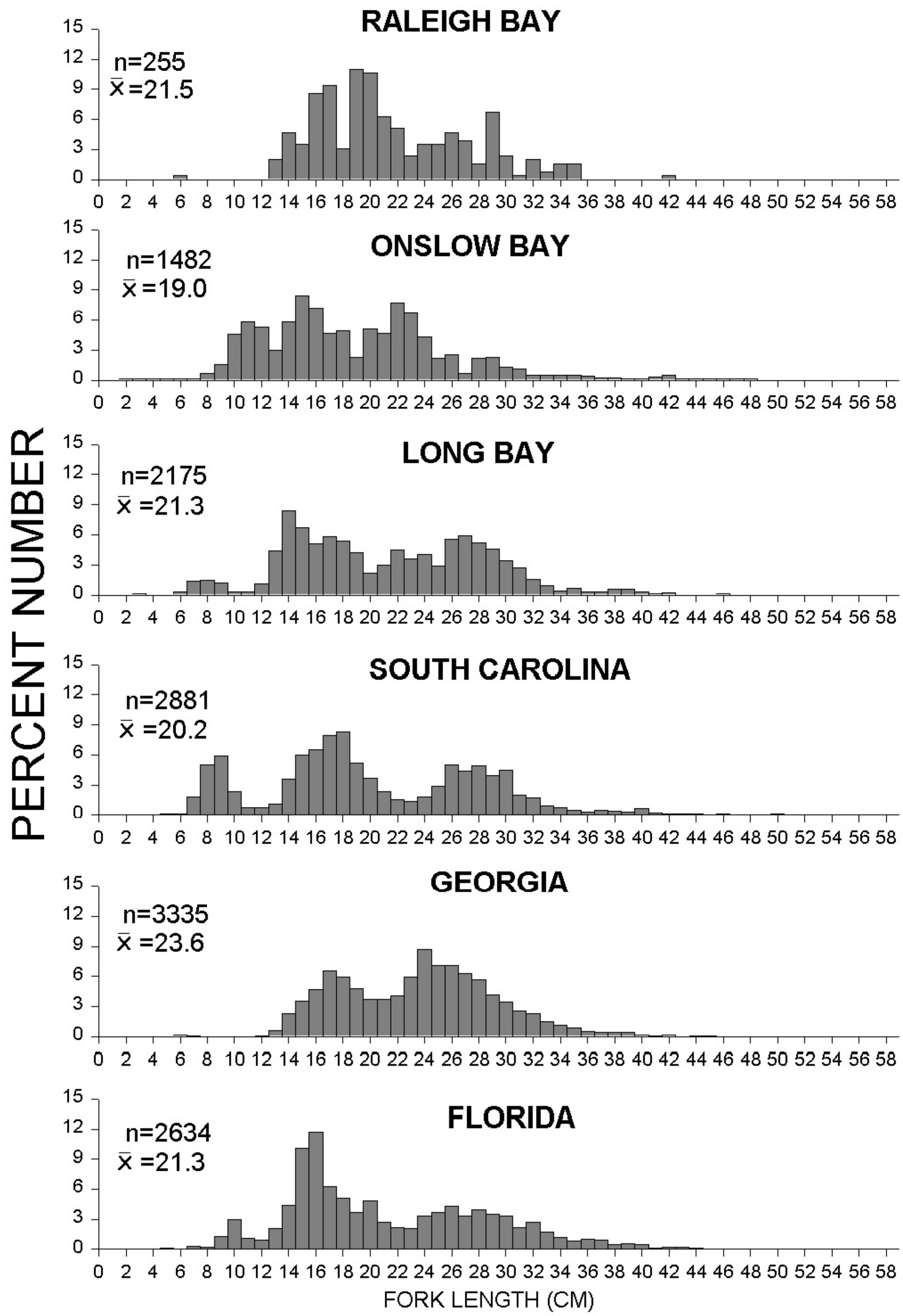



Figure 64. Regional length-frequencies of *Scomberomorus maculatus* in inner strata 1990-1999.

**Distribution and Abundance of Priority Decapod Crustacean Species**

***Callinectes sapidus***

Ranging from Nova Scotia to northern Argentina, *C. sapidus* is an amphi-Atlantic species, with introduced individuals occurring in parts of Europe and the Mediterranean Sea (Williams, 1984). The blue crab is a euryhaline species found in oligohaline, estuarine, and shallow oceanic waters and common on sandy and muddy bottoms. This species supports important commercial and recreational fisheries (Eldridge and Waltz, 1977; Williams, 1984; Low et al., 1987).

Inner strata yielded a total of 4615 (0.6 individuals/ha) blue crabs weighing 683 kg (0.08 kg/ha) (Table 8). Overall density of *C. sapidus* peaked in 1990, followed by several years of low abundance and a secondary peak in 1999 (Figure 65); however, densities did not differ significantly among years ($X^2 = 16.9$, $p > 0.05$). Seasonal and regional densities were found to be significantly different (seasons: $X^2 = 37.9$, $p < 0.0001$; regions: $X^2 = 70.0$, $p < 0.0001$). The highest seasonal density was observed during summer cruises and the greatest regional density of individuals occurred in Raleigh Bay. Only 155 specimens were taken in outer strata (spring: n = 43, $\bar{X}$/ha = 0.04; fall: n = 112, $\bar{X}$/ha = 0.19).

Carapace widths of *C. sapidus* ranged from 1 to 20 cm ($\bar{X} = 13.8$, n = 4613). Carapace width was significantly different among seasons ($X^2 = 47$, $p < 0.0001$), with greatest seasonal mean length in spring and smallest in summer (Figure 66). Carapace width varied significantly among regions ($X^2 = 90$, $p < 0.0001$), with mean widths greater in the southern SAB (Figure 67).

Males constituted less than 3% of the blue crab catch. The tendency of males to inhabit lower salinity estuarine waters explains their lesser importance in offshore catches (Low et al., 1987). Only 3 males were taken in the outer depth-zone.

The ratio of ovigerous to nonovigerous females was not independent of season ($G = 864$, $p < 0.001$) or region ($G = 171$, $p < 0.001$). The percentage of ovigerous females with advanced stage eggs (brown) was greatest in spring in all regions except Onslow Bay (Figure 68). Non-ovigerous females outnumbered ovigerous females in summer and fall and in all regions, except Long Bay and Florida. Fall collections produced the fewest ovigerous females, especially in the southern SAB. Regionally, the greatest number of ovigerous females was taken in spring and summer off South Carolina. Only 20 females with egg remnants were taken in 1990-1999.

Table 8. Estimates of density (number of individuals/hectare) for priority decapod crustacean species among regions and seasons for inner strata 1990 -1999.

*Callinectes sapidus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0.04 | 5.2 | 0.3 | 1.8 |
| Onslow Bay | 0.04 | 1.6 | 0.6 | 0.7 |
| Long Bay | 0.02 | 0.5 | 0.07 | 0.2 |
| South Carolina | 0.6 | 1.0 | 1.0 | 0.9 |
| Georgia | 0.03 | 0.5 | 0.3 | 0.2 |
| Florida | 0.06 | 0.9 | 0.02 | 0.3 |
| Season | 0.2 | 1.1 | 0.4 | 0.6 |

*Farfantepenaeus aztecus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 0 | 29.1 | 23.6 | 17.1 |
| Onslow Bay | 0.01 | 24.1 | 7.2 | 10.4 |
| Long Bay | 0.01 | 7.1 | 1.2 | 2.7 |
| South Carolina | 0.05 | 12.7 | 2.7 | 5.1 |
| Georgia | 0.5 | 3.2 | 1.3 | 1.7 |
| Florida | 1.6 | 0.6 | 0.3 | 0.8 |
| Season | 0.3 | 10.3 | 3.4 | 4.6 |

*Farfantepenaeus duorarum*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 3.5 | 13.3 | 3.2 | 6.6 |
| Onslow Bay | 4.4 | 0.3 | 1.6 | 2.2 |
| Long Bay | 2.1 | 0.09 | 0.6 | 1.0 |
| South Carolina | 0.9 | 0.1 | 0.2 | 0.4 |
| Georgia | 0.4 | 0.002 | 0.07 | 0.2 |
| Florida | 0.04 | 0.07 | 0.03 | 0.05 |
| Season | 1.5 | 0.8 | 0.6 | 1.0 |

*Litopenaeus setiferus*

| | Spring | Summer | Fall | Region |
|---|---|---|---|---|
| Raleigh Bay | 1.9 | 0.5 | 13.8 | 5.3 |
| Onslow Bay | 1.0 | 0.4 | 25.2 | 8.7 |
| Long Bay | 1.1 | 1.8 | 28.6 | 10.5 |
| South Carolina | 11.5 | 4.9 | 47.6 | 21.3 |
| Georgia | 18.0 | 4.0 | 29.2 | 17.1 |
| Florida | 2.9 | 8.6 | 25.4 | 12.1 |
| Season | 7.8 | 3.8 | 32.5 | 14.6 |

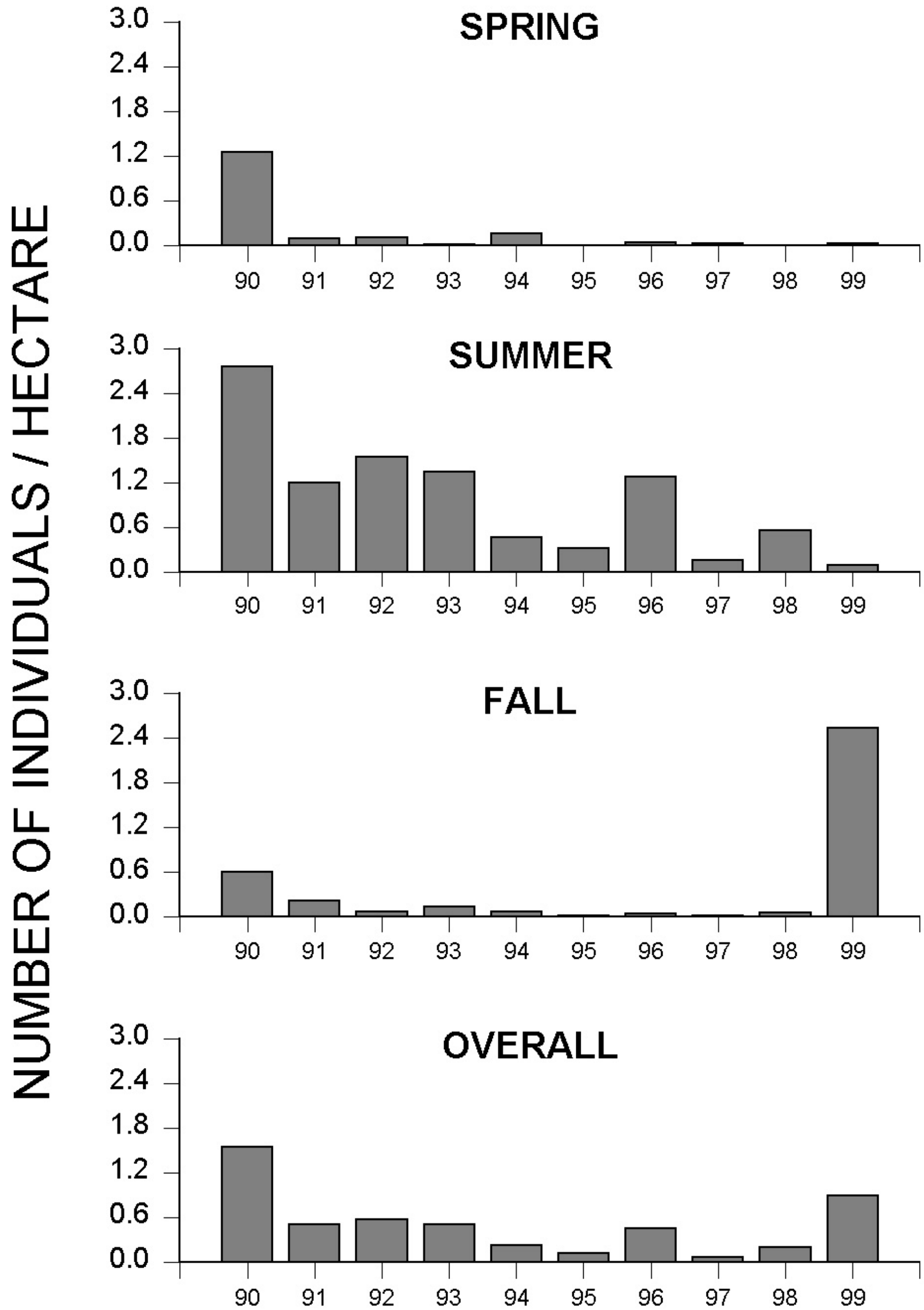



Figure 65. Annual densities of *Callinectes sapidus* from inner strata

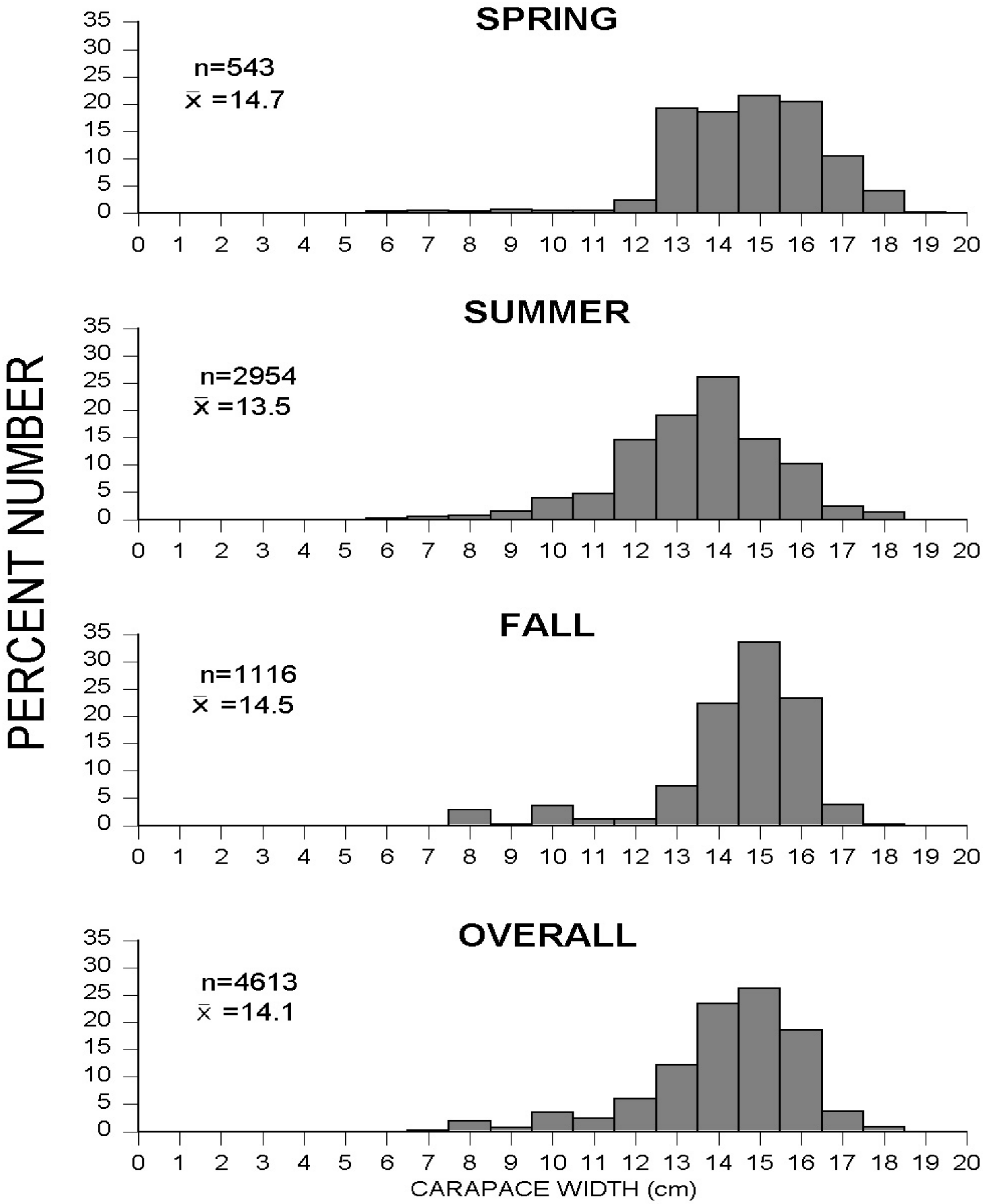



Figure 66. Seasonal length-frequencies of *Callinectes sapidus* in inner strata 1990-1999.

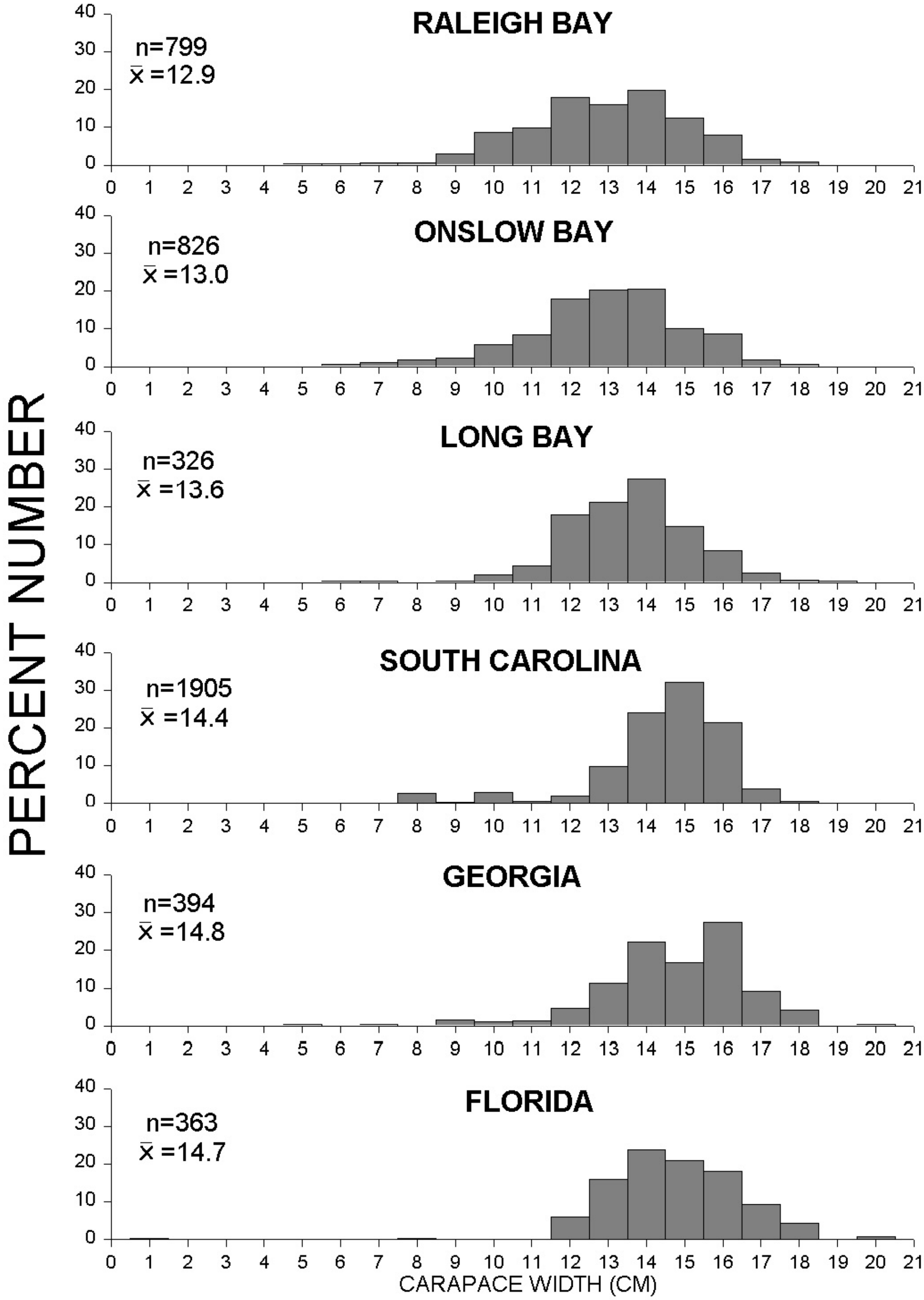



Figure 67. Regional length-frequencies of *Callinectes sapidus* in inner strata 1990-1999.

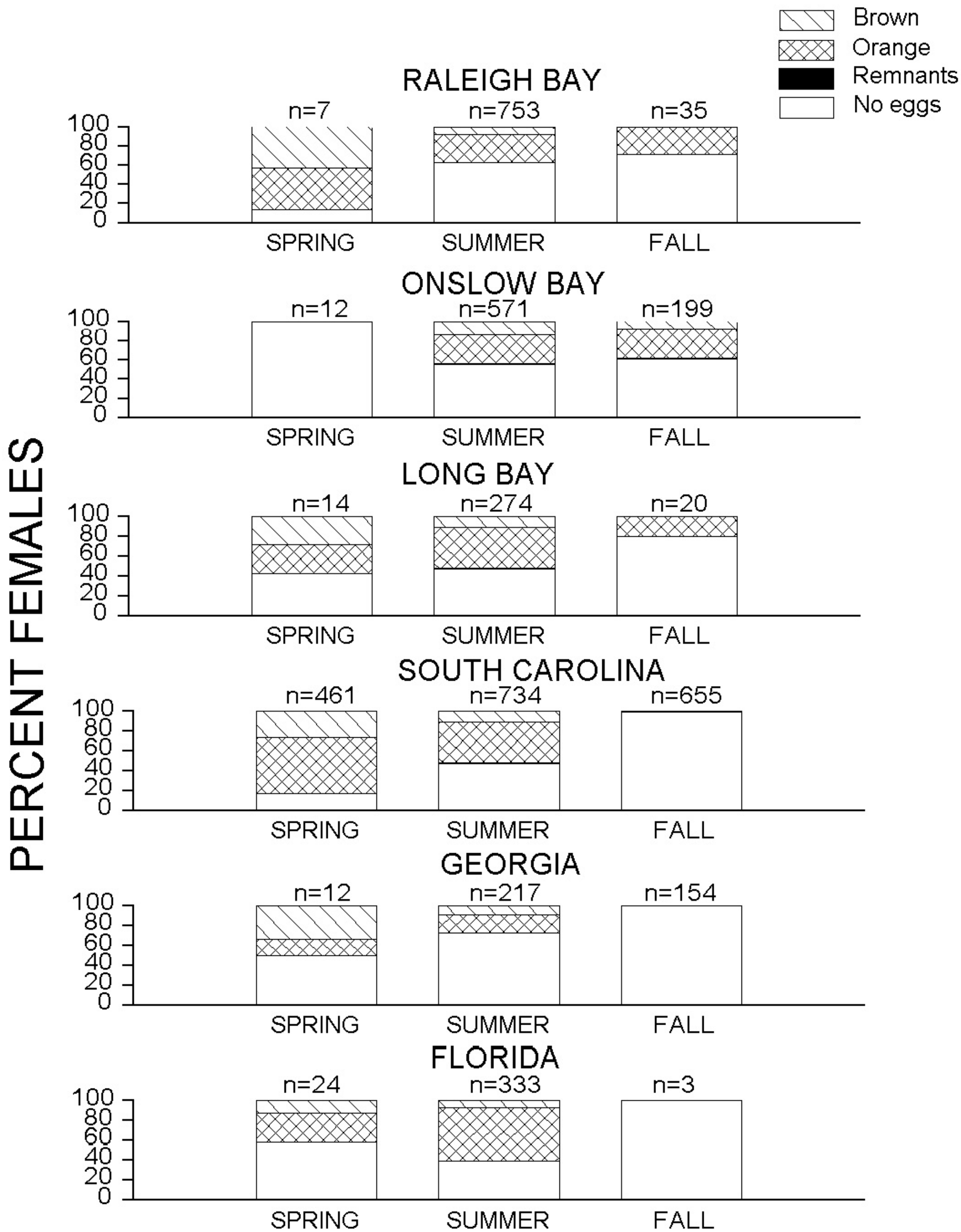



Figure 68. Developmental state of eggs of *Callinectes sapidus* from inner strata by season and region.

***Farfantepenaeus aztecus***

Brown shrimp, formerly *Penaeus aztecus* (Perez-Farfante and Kensley, 1997), occur from Martha's Vineyard, Massachusetts, to the Florida Keys and around the Gulf of Mexico to northwestern Yucatan (Perez-Farfante, 1978; Williams, 1984). The spawning of brown shrimp is protracted and the time varies regionally, but generally occurs in fall and winter (Williams, 1984). The species supports a seasonal fishery along the mid-Atlantic states, but is most important commercially in the Gulf of Mexico off the coast of Texas (Perez-Farfante, 1978; South Atlantic Fishery Management Council, 1981; Renfro and Brusher, 1982).

The brown shrimp ranked second among decapod crustaceans in inner strata, with 36,489 specimens (4.6 individuals/ha) collected weighing 590 kg (0.07 kg/ha). The density of brown shrimp peaked in 1996 (Figure 69), due to a record catch in the summer of that year. Density was found to vary significantly among years ($X^2 = 54.6$, $p < 0.005$), seasons ($X^2 = 87.9$, $p < 0.0001$), and regions ($X^2 = 91.8$, $p < 0.0001$). Summer collections produced the highest seasonal density (Table 8). The greatest regional density of brown shrimp occurred in Raleigh and Onslow Bays, although no brown shrimp were collected in Raleigh Bay in spring. The overall seasonal pattern of abundance of brown shrimp includes small spring catches, followed by larger summer catches, and moderately-sized fall catches. Outer strata produced 1301 brown shrimp (spring: n = 670, $\overline{X}$/ha = 0.62; fall: n = 631, $\overline{X}$/ha = 1.07).

Total lengths of *F. aztecus* ranged from 3 to 22 cm with a mean length of 12.1 cm (n = 36,489). Total lengths differed significantly among seasons ($X^2 = 87$, $p < 0.0001$), with mean length increasing from spring to fall (Figure 70) Lengths were also significantly different among regions ($X^2 = 114$, $p < 0.0001$). Mean lengths ranged from 11.1 cm in waters off Florida to 12.6 cm in Raleigh Bay (Figure 71 ).

Less than 8% of the male brown shrimp had fully developed spermatophores (ripe), and less than 1% of the females had ripe ovaries (Figure 72). Spermatophore development was not independent of season ($G = 1283$, $p < 0.001$) or region ($G = 819$, $p < 0.001$). The percentage of ripe males was greatest in fall. The ratio of ripe to nonripe females was not independent of season ($G = 2658$, $p < 0.001$) or region ($G = 564$, $p < 0.001$); the percentage of females with ripe ovaries increased from spring to fall. Only 3% of the female brown shrimp were found to be mated.

In outer strata ripe males were most numerous in fall (84%) , when few females with ripe ovaries were collected (2%) (Figure 73). However, approximately 15% of all females in outer strata were found to be mated, only one of which had ripe ovaries. All of the mated female brown shrimp collected outer strata were taken in fall trawls.

Outer strata off North Carolina were sampled in fall primarily for the purpose of gathering data on the reproductive condition of brown shrimp. Ripe individuals collected in contiguous depth-zones made up less than 18% of the female brown shrimp collected and only 12% of males. Only 18% of the females taken in comparable depth-zones in fall were mated.

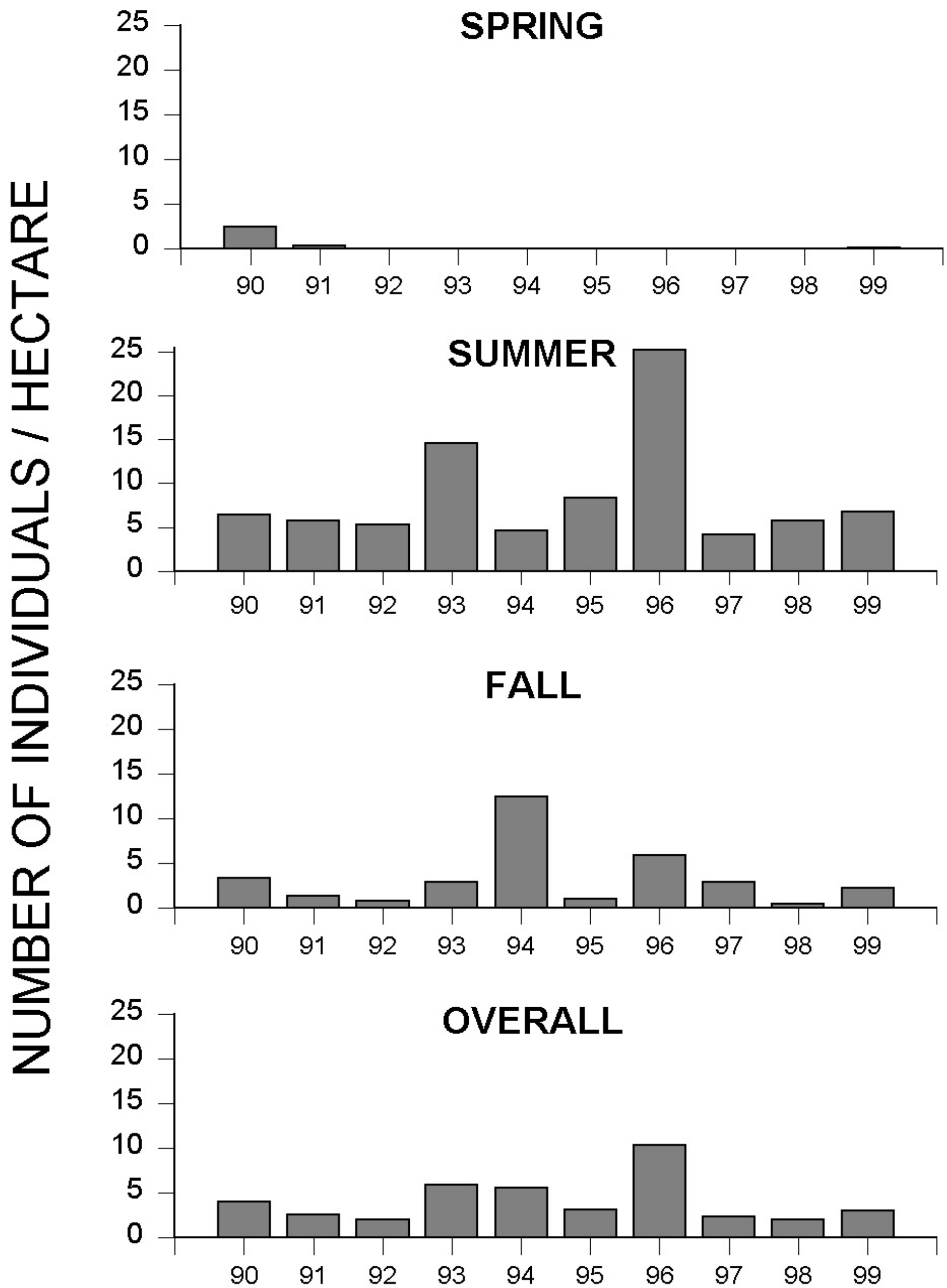



Figure 69. Annual densities of *Farfantepenaeus aztecus* from inner strata

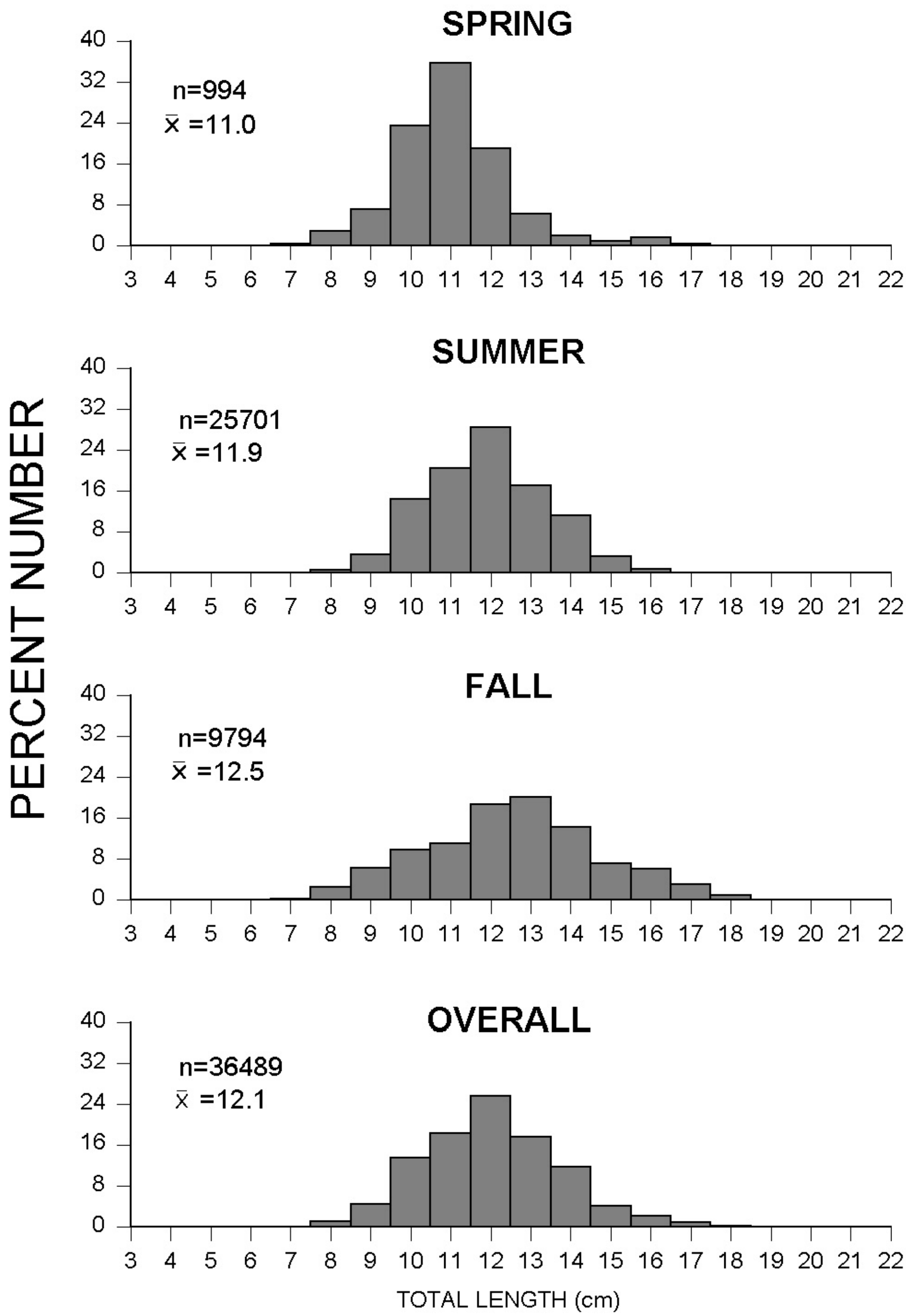



Figure 70. Seasonal length-frequencies of *Farfantepenaeus aztecus* in inner strata 1990-1999.

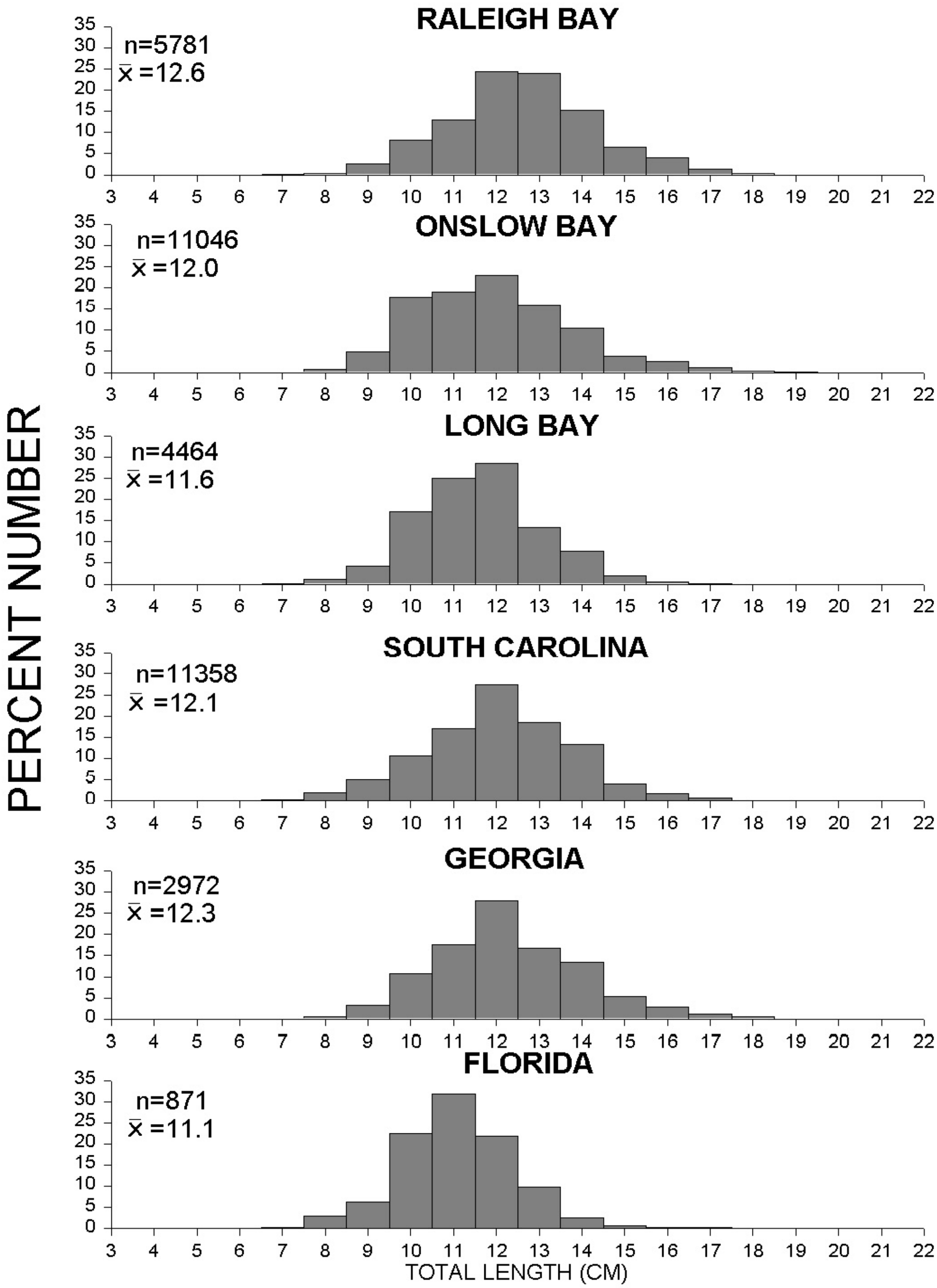



Figure 71. Regional length-frequencies of *Farfantepenaeus aztecus* in inner strata 1990-1999.

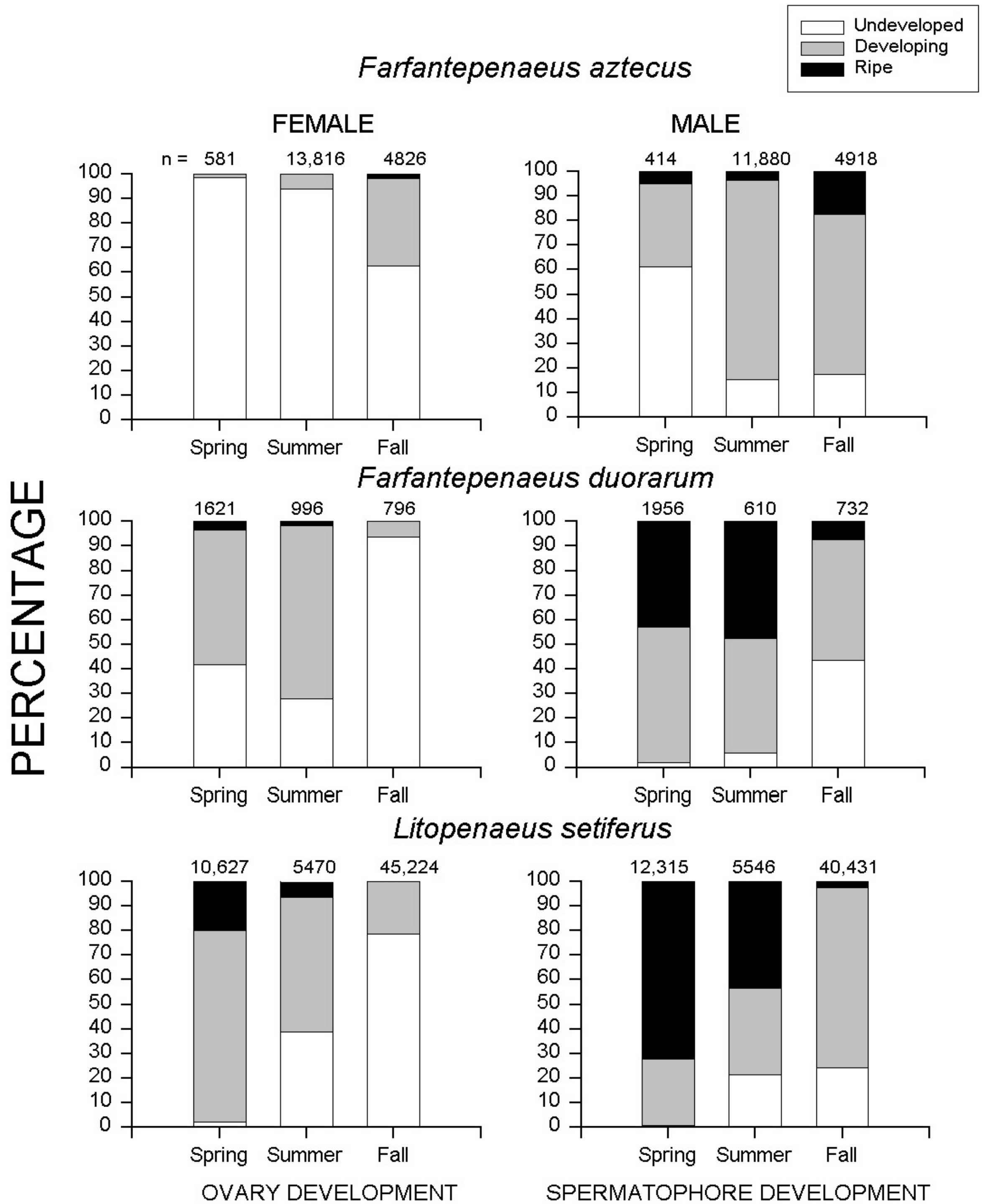



Figure 72. Gonadal development of penaeid shrimp species from inner strata.

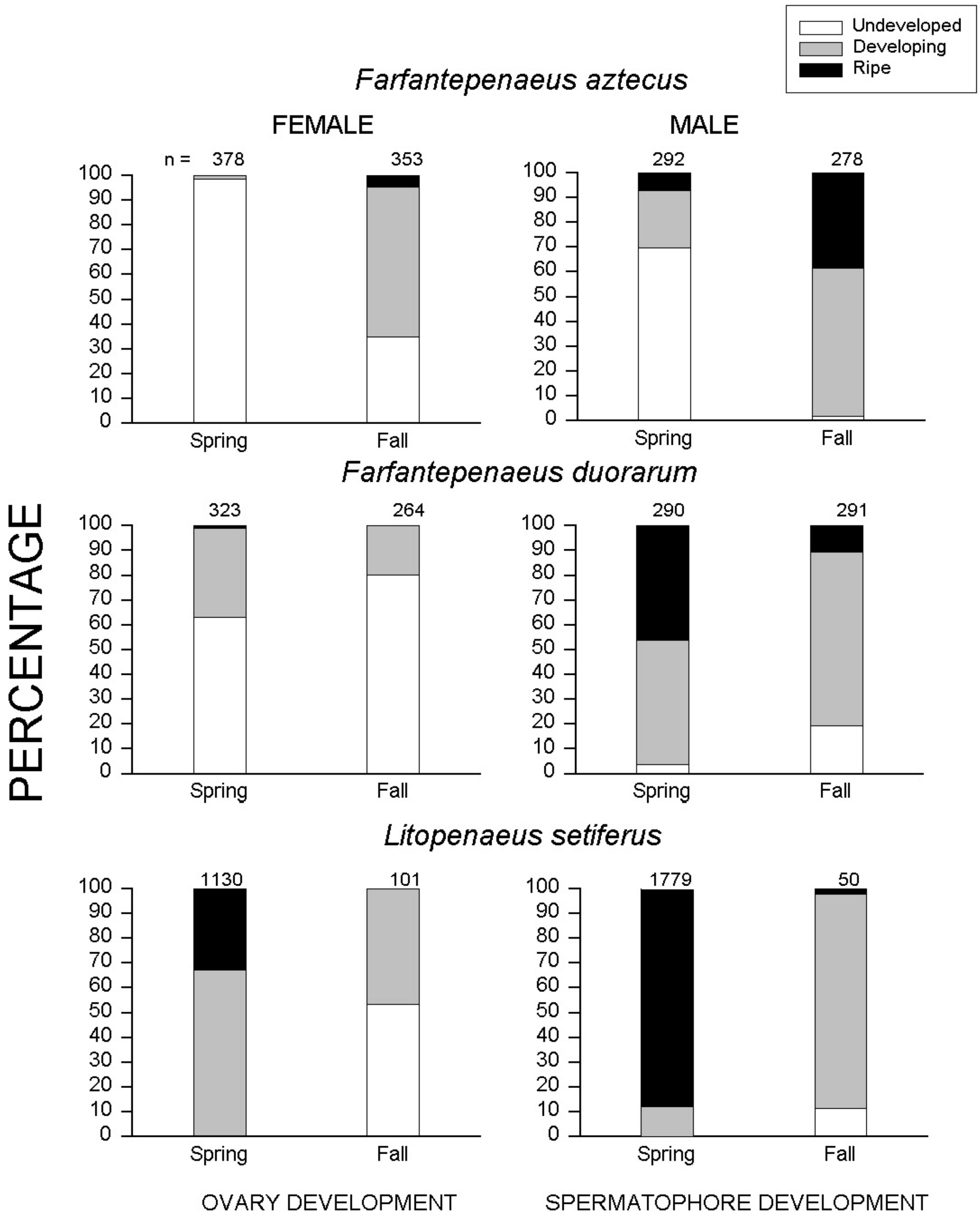



Figure 73. Gonadal development of penaeid shrimp species from outer strata.

***Farfantepenaeus duorarum***

Pink shrimp, formerly *Penaeus duorarum* (Perez-Farfante and Kensley, 1997), are found from Chesapeake Bay to the Florida keys and throughout the Gulf of Mexico to the Yucatan peninsula (Perez-Farfante, 1978; Williams, 1984). They are most abundant in waters off the Gulf coast of Florida, in the Bay of Campeche, and in waters off North Carolina (Perez-Farfante, 1978; Williams, 1984).

The pink shrimp was the least abundant commercially important penaeid shrimp species collected during 1990-1999. The 6852 specimens (1.0 individuals/ha) taken from inner strata weighed 108 kg (0.02 kg/ha). Density did differ significantly among years ($X^2 = 81.4$, $p < 0.0001$), with a peak in annual density in 1995 (Figure 74). Although densities of abundance did not differ significantly among seasons ($X^2 = 1.2$, $p > 0.5$), abundance was significantly different among regions ($X^2 = 81.4$, $p < 0.0001$). Regional densities were observed to decrease from Raleigh Bay southward (Table 8). A total of 1175 *F. duorarum* were taken in outer strata (spring: n = 614, $\bar{X}$/ha = 0.57; fall: n = 561, $\bar{X}$/ha = 0.95).

Total length of pink shrimp ranged from 6 to 20 cm ($\bar{X}$ = 11.7 cm, n = 6852). Total lengths varied significantly among seasons ($X^2 = 252$, $p < 0.0001$). Mean lengths increased from 11.0 cm in spring to 12.5 cm in fall (Figure 75). Total length did differ significantly among regions ($X^2 = 189$, $p < 0.0001$). Regionally, mean lengths ranged from 11.1 cm in Florida to 12.9 cm in Raleigh Bay (Figure 76).

In inner strata approximately 36% of male pink shrimp sampled had fully developed spermatophores (Figure 72). Spermatorphore development was not independent of season ($G = 948$, $p < 0.001$) or region ($G = 72$, $p < 0.001$). Burukovskii and Bulanenkov (1971) reported that spawning activity of pink shrimp in North Carolina waters peaked in spring. The ratio of ripe to nonripe females was not independent of season ($G = 1001$, $p < 0.001$) or region ($G = 72$, $p < 0.001$). All of the ripe female pink shrimp were collected in spring and summer. Although approximately 20% of the total number of female pink shrimp sampled were mated, only twenty-nine individuals (less than 1%) were both ripe and mated. Like brown shrimp, copulation in pink shrimp may occur regardless of developmental stage of the ovaries (Perez-Farfante, 1969). In outer strata spring collections produced most of the ripe males (82%), but few females with ripe ovaries (n=3) (Figure 73). In outer strata approximately 7% of female pink shrimp were found to be mated, although none were both ripe and mated.

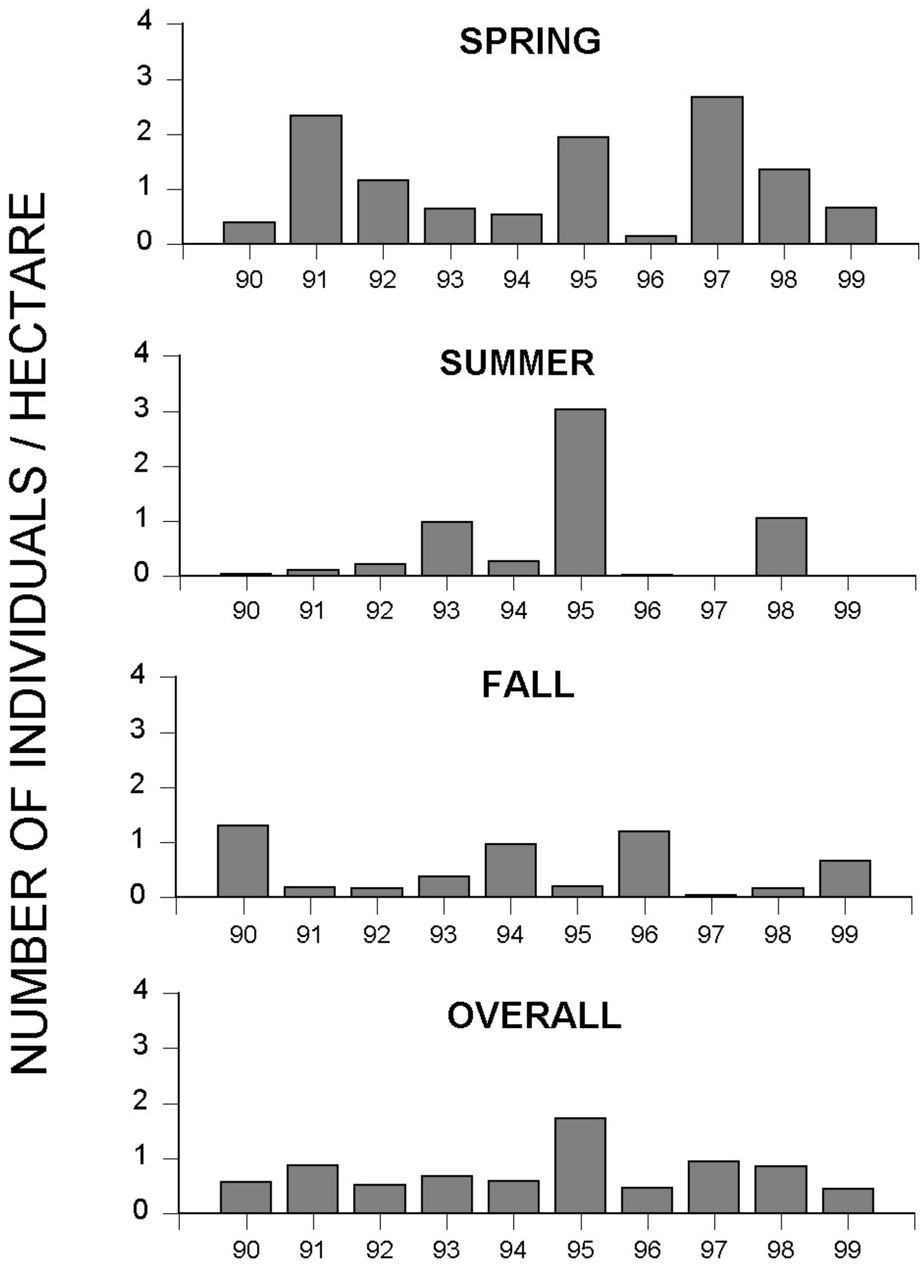



Figure 74. Annual densities of *Farfantepenaeus duorarum* from inner strata

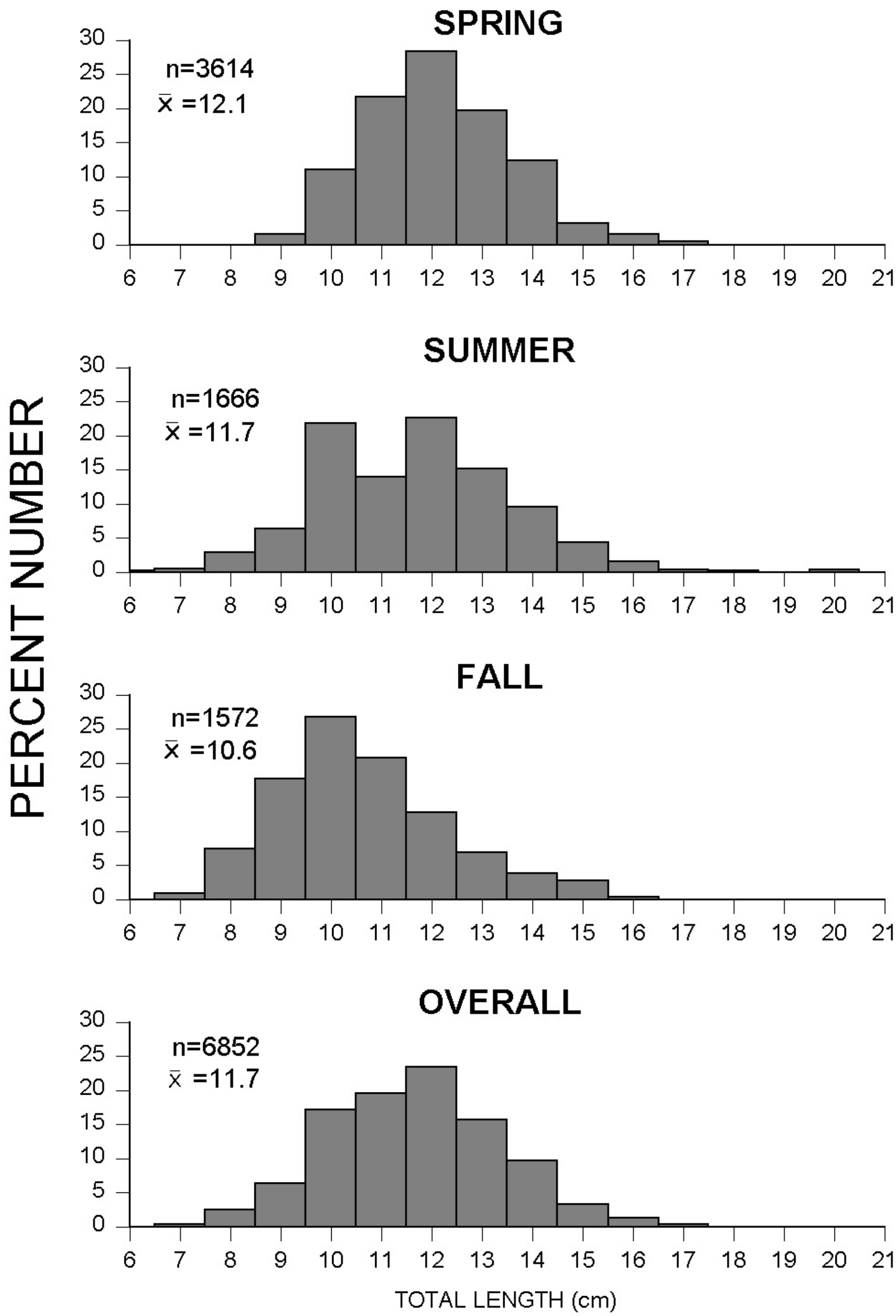



Figure 75. Seasonal length-frequencies of *Farfantepenaeus duorarum* in inner strata 1990-1999.

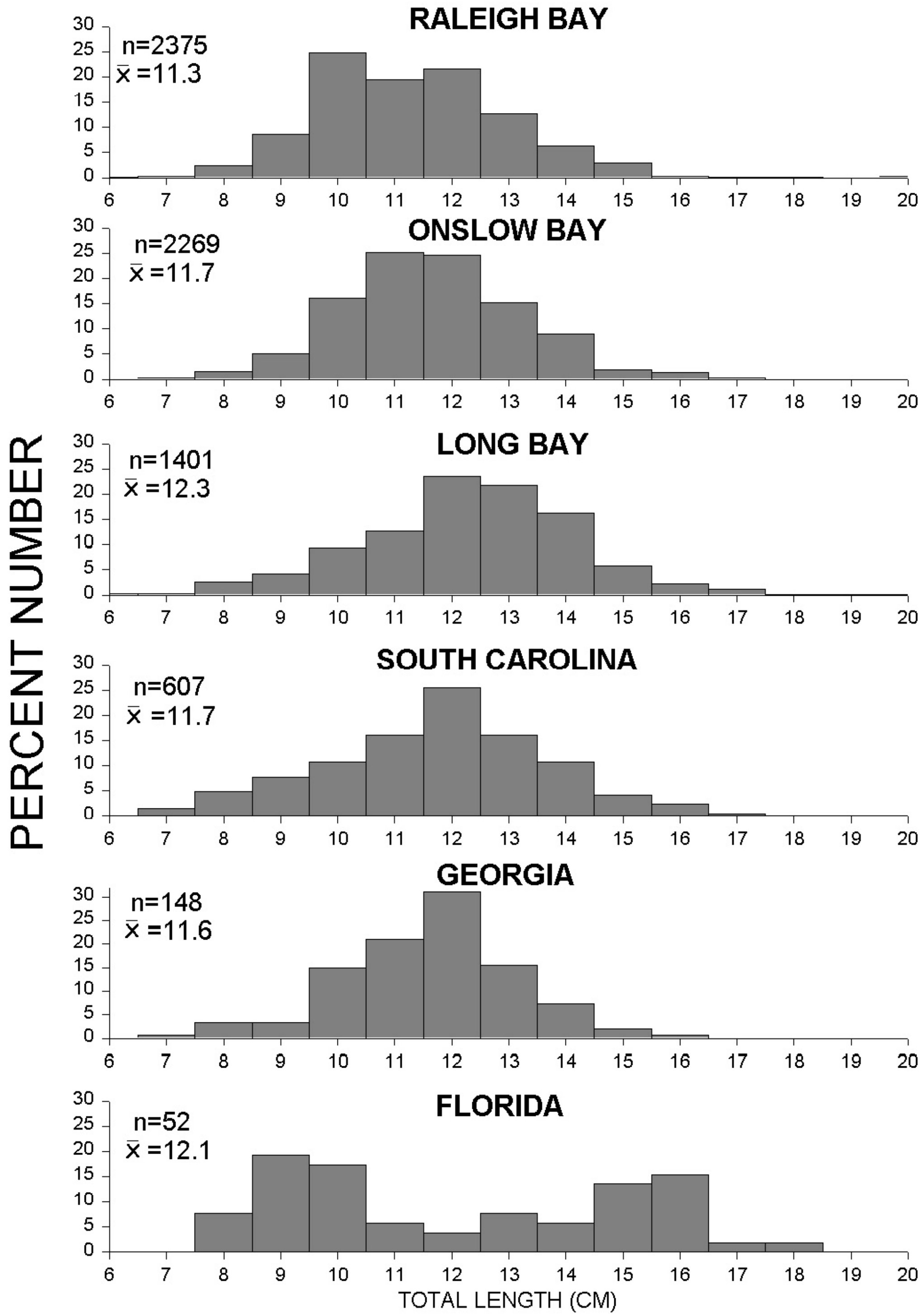



Figure 76. Regional length-frequencies of *Farfantepenaeus duorarum* in inner strata 1990-1999.

### *Litopenaeus setiferus*

The geographical range of white shrimp, formerly *Penaeus setiferus* (Perez-Farfante and Kensley, 1997), extends from New York to southern Florida and throughout the Gulf of Mexico (Perez-Farfante, 1978; Williams, 1984). White shrimp spawning in the SAB begins in May and continues into September (Lindner and Anderson, 1956; Williams, 1984). Centers of abundance along the Atlantic coast of the United States are found in waters off northeastern Florida, Georgia, and South Carolina (Perez-Farfante, 1978; Williams, 1984), where the species supports a large commercial fishery (South Atlantic Fishery Management Council, 1981).

White shrimp was the most abundant commercially important decapod crustacean species from inner strata in the SEAMAP-SA Trawl Survey and ranked fifth in abundance overall, with 119,926 (14.7 individuals/ha) weighing 2994 kg (0.4 kg/ha). Annual ($X^2 = 62.3$, $p < 0.0001$), seasonal ($X^2 = 141.7$, $p < 0.0001$), and regional ($X^2 = 53.5$, $p < 0.0001$) densities were found to vary significantly. The annual density of abundance of *L. setiferus* in 1999 was the greatest annual density in the history of the survey (76). Density was highest in fall collections (Table 8). Greatest regional densities of abundance were found off South Carolina and Georgia. Outer strata produced 3066 white shrimp, the majority of which (95) were taken in spring collections in the southern SAB (spring: $n = 2915$, $\bar{X}$/ha = 2.71; fall: $n = 151$, $\bar{X}$/ha = 0.26).

Total lengths of *L. setiferus* ranged from 4 to 20 cm, with a mean length of 14.5 cm ($n = 119,925$). There was a significant difference in mean length among seasons ($X^2 = 280$, $p < 0.0001$) (Figure 78), with mean length greatest in spring. Smaller YOY individuals began moving out of the estuaries in summer and continued to do so into the fall. *L. setiferus* inhabits estuaries until nearing maturity when they move offshore (Williams, 1984), where they are susceptible to capture by our gear. Regional mean lengths also differed significantly ($X^2 = 189$, $p < 0.0001$). Florida produced the smallest mean length (13.9 cm) and Raleigh Bay the greatest (15.8 cm) (Figure 79).

White shrimp are reported to spawn from May through September in the SAB (Lindner and Anderson, 1956; Williams, 1984). The percentage of males with fully developed spermatophores peaked in spring, decreasing to 3% in fall, when over half (69%) of the males taken were collected (Figure 72). The ratio of males with fully developed spermatophores to those with spermatophores not yet fully developed was not independent of seasons ($G = 29883$, $p < 0.001$) or regions ($G = 8819$, $p < 0.001$). Only 4% of females collected in inner strata had ripe ovaries, and only three of the white shrimp females collected were ripe in fall, when 74% of the females were taken. The ratio of ripe to nonripe females was not independent of season ($G = 29134$, $p < 0.001$) or region ($G = 6359$, $p < 0.001$). The percentage of ripe females peaked in spring (20%), decreasing in subsequent seasons. Less than 1% of the females taken in SEAMAP-SA trawls were mated.

Spring collections produced all of the ripe males (with the exception on one individual in fall) and all of the females with ripe ovaries taken in outer strata (Figure 73). Five percent of the females taken in outer strata were found to be mated, all of which were found to have ripe ovaries.

Outer strata in the southern half of the SAB sampled only in spring for the purpose of collecting data on spawning of white shrimp produced less than 18% of the ripe females and only 19% of ripe males collected in comparable depth-zones. Less than 26% of the female white shrimp sampled in contiguous depth-zones in the spring were found to be mated.

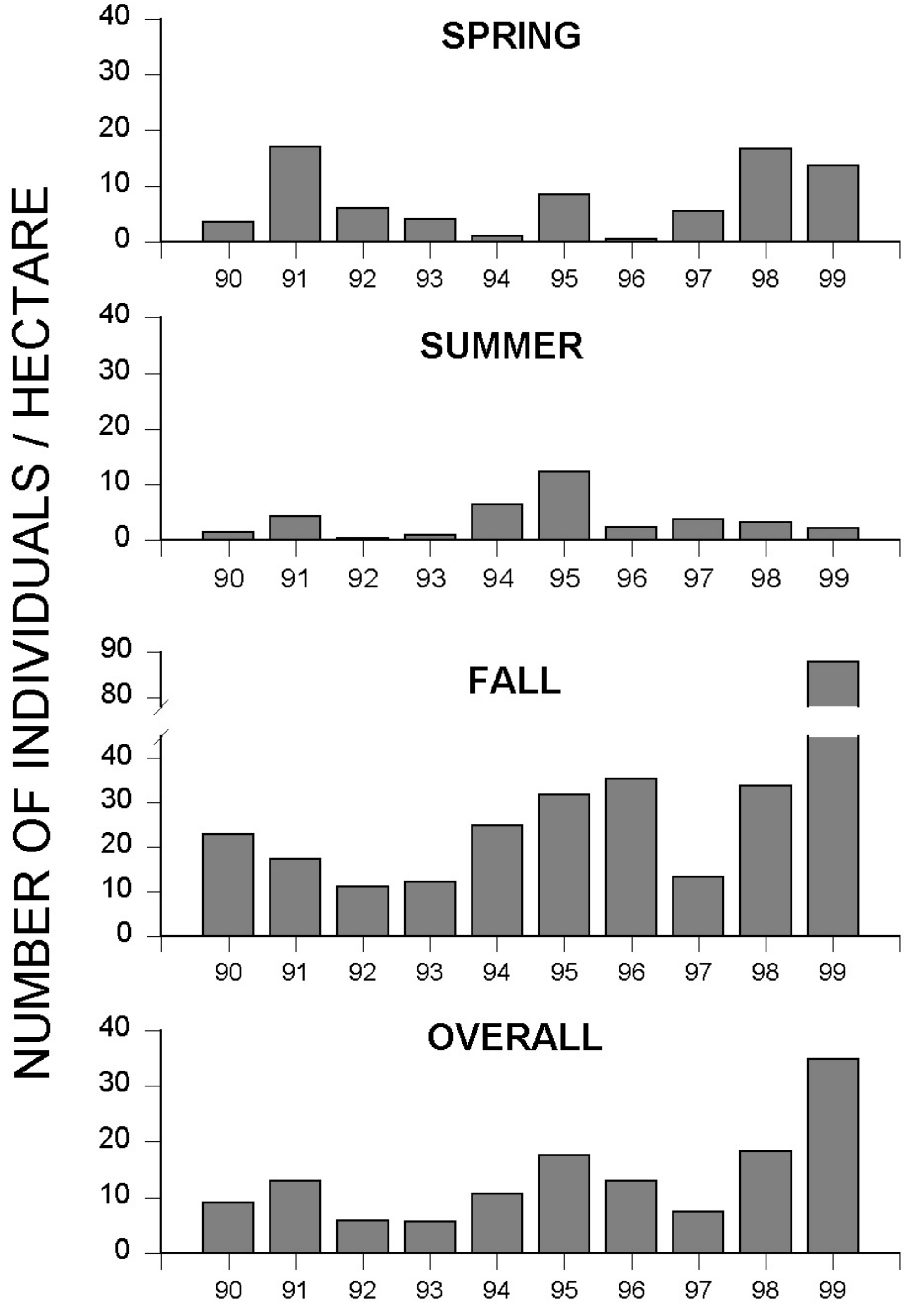



Figure 77. Annual densities of *Litopenaeus setiferus* from inner strata

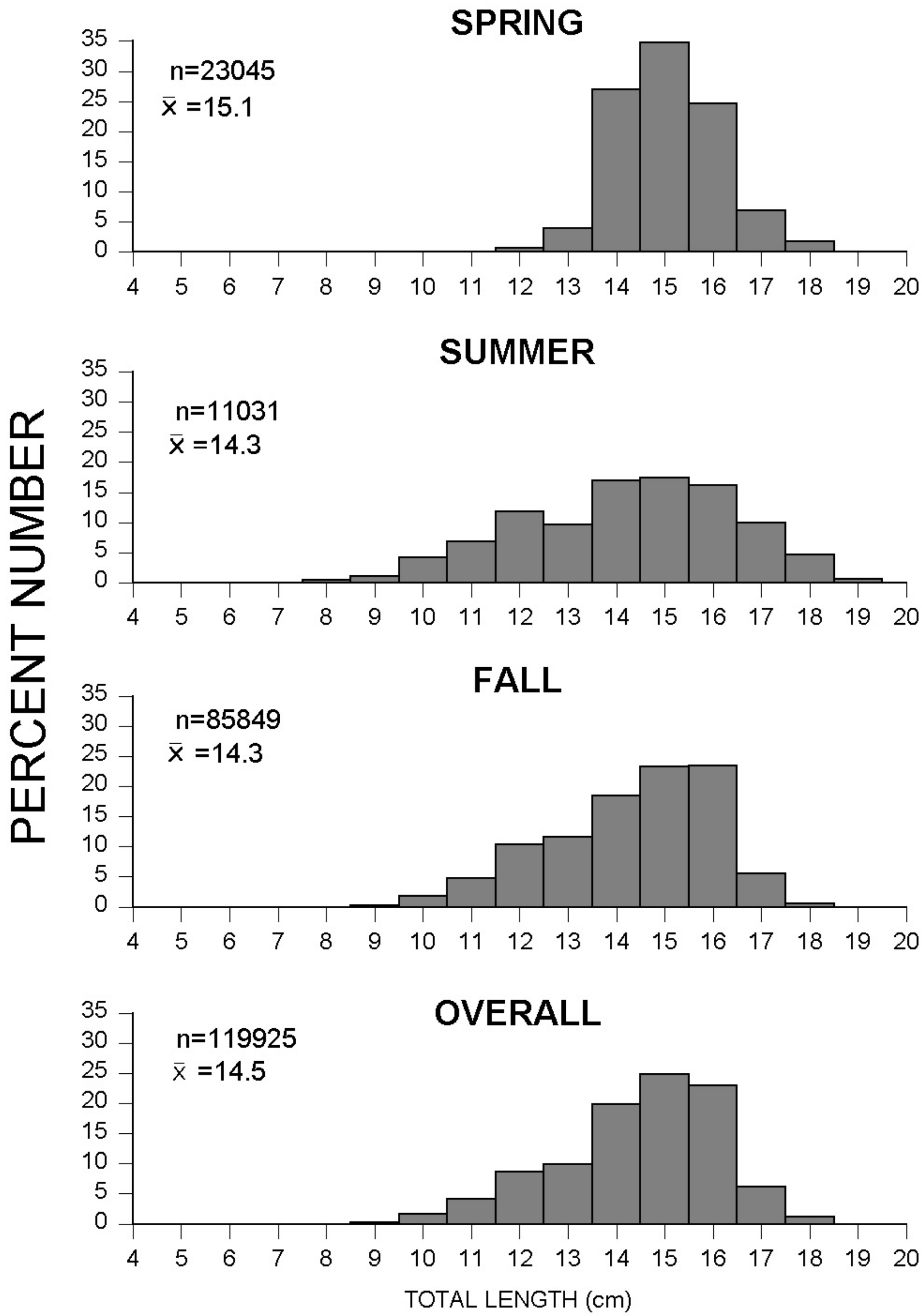



Figure 78. Seasonal length-frequencies of *Litopenaeus setiferus* in inner strata 1990-1999.

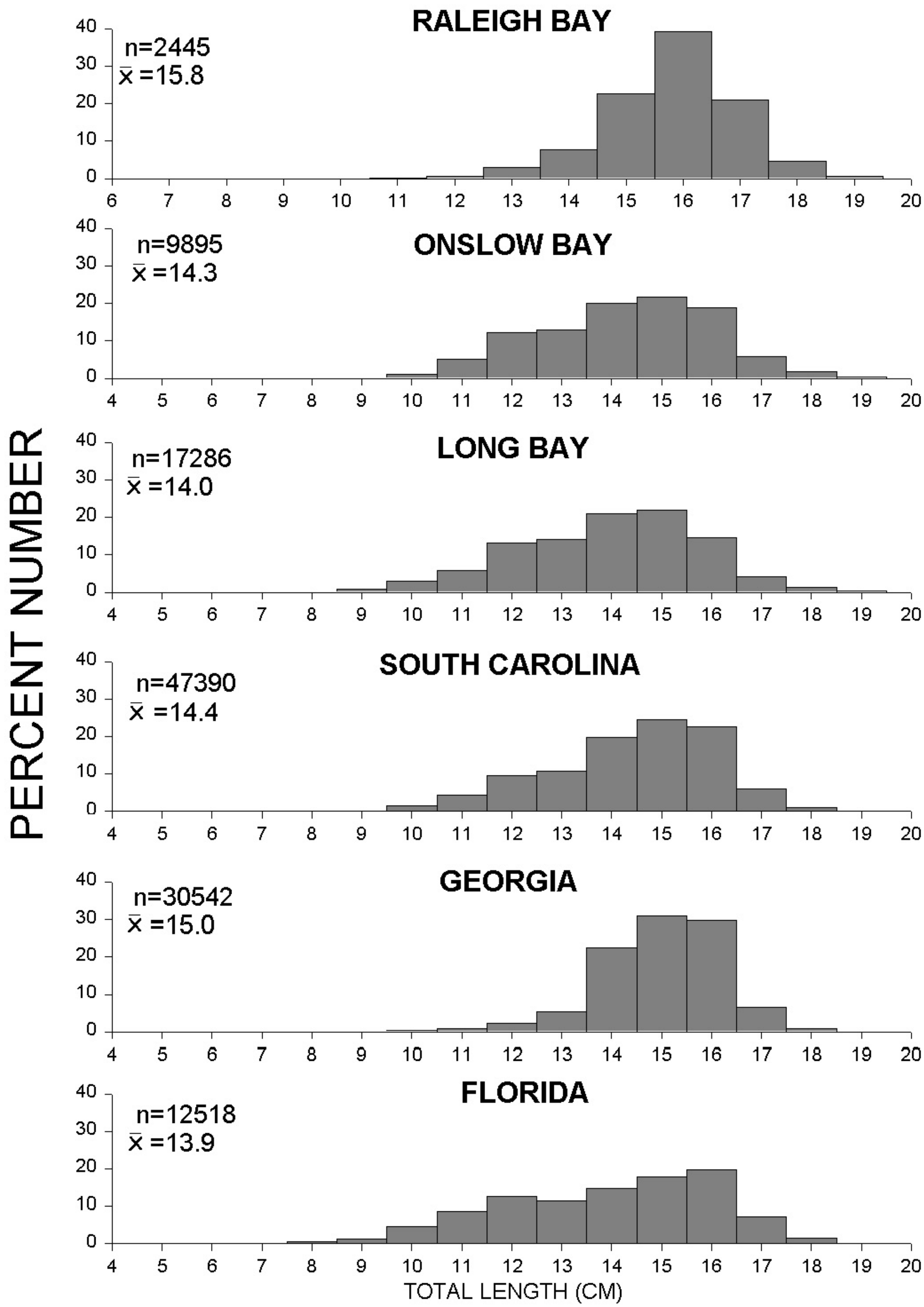



Figure 79. Regional length-frequencies of *Litopenaeus setiferus* in inner strata 1990-1999.

## CONCLUSIONS

- A total of 322 species collected from 1990-1999 (inner strata: 296 species; outer strata: 272 species)

- Number of species varied little seasonally for inner strata

- Greatest number of species was found in Long Bay

- Inner strata yielded 1326 individuals/tow (345 individuals/ha); greatest densities occurred in Raleigh Bay and decreased southward to Georgia.

- Finfish catches were dominated by spot and Atlantic croaker; decapod catches were dominated by white shrimp.

- Abundance in the outer depth-zone was lower than that found in inner strata; however, spring abundance was sometimes high, probably due to the proximity to shore of outer strata off Florida. Spot and Atlantic croaker were numerically important in outer depth zones in that region.

- Among target species collected, sheepshead, spotted seatrout, black drum, and red drum were rarely caught in collections.

- Outer strata sampled in the southern half of the SAB only in spring for the purpose of collecting data on spawning of white shrimp and in fall off North Carolina to gather data on the reproductive condition of brown shrimp yielded few ripe males or females (<20%) or mated females (<25%) compared to contiguous inner strata sampled during the same season.

**ACKNOWLEDGMENTS**

We appreciate the administrative assistance of David Whitaker, David Cupka, and Wayne Waltz and the recommendations of the SEAMAP-SA Committee and the Shallow Water Trawl Workgroup. Mike Schwarz and Jeff Jacobs were instrumental in the successful completion of SEAMAP-SA cruises through their able operation of the R/V *Lady Lisa*.

## APPLICATIONS OF SEAMAP SPECIMENS AND DATA

Cooperative Study:

As part of a cooperative MARFIN project entitled Age, Growth, And Reproductive Biology of Selected Fishes Caught Incidentally in the Penaeid Shrimp Trawl Fishery along the Southeastern Coast of the United States, data on the age structure of spot, Atlantic croaker, and weakfish were gathered to produce an age-length key for those species.

Educational/Graduate Student Research:

- Sciaenid blood and fin for standards for species identification of sciaenids through genetic analysis of fish eggs
- Age, growth, and fecundity study of *Cynoscion regalis*
- Age/growth and reproduction study of *Rhizoprionodon terraenovae*
- Life history / fecundity studies of several flatfish species
- Comparative otolith morphology of *Cynoscion regalis* and *Cynoscion nothus*
- Study of morphology/proteins of ray spines
- Reference collections of common decapod crabs, flatfish, all SEAMAP species
- Stock identification of Juvenile *Scomberomorus cavalla*
- Comparative morphology of *Arius felis* and *Bagre marinus*
- Field key development and genetic comparison of *Loligo* spp. and *Loliguncula brevis*

Stock Assessment/VPA:

| | |
|---|---|
| *Brevoortia tyrannus* | *Pomatomus saltatrix* |
| *Cynoscion regalis* | *Rhinoptera bonasus* |
| *Micropogonias undulatus* | *Scomberomorus maculatus* |
| *Paralichthys lethostigma* | All shark species collected |

Life History (Age/Growth, Reproduction):

| | |
|---|---|
| *Balistes capriscus* | *Micropogonias undulatus* |
| *Centropristis striata* | *Paralichthys dentatus* |
| *Cynoscion regalis* | *Paralichthys lethostigma* |
| *Etropus crossotus* | *Pomatomus saltatrix* |
| *Leiostomus xanthurus* | *Rachycentron canadum* |
| *Lutjanus campechanus* | *Scomberomorus maculatus* |
| *Menticirrhus americanus* | *Scomberomorus cavalla* |

Genetics / Species Identification Studies:

*Aetobatus narinari*
*Alopias vulpinus*
*Brevoortia smithi*
*Callinectes ornatus*
*Carcharhinus acronotus*
*Carcharhinus brevipinna*
*Carcharhinus isodon*
*Carcharhinus leucus*
*Carcharhinus limbatus*
*Carcharhinus obscurus*
*Carcharhinus plumbeus*
*Cynoscion nothus*
*Cynoscion regalis*
*Dasyatis spp.*
*Mustelus canis*
*Myleobatis freminvillei*
*Odontaspis taurus*
*Portunus spinimanus*
*Rhinoptera bonasus*
*Rhizoprionodon terraenovae*
*Sardinella aurita*
*Sphyrna lewini*
*Sphyrna tiburo*
*Squatina dumeril*

Genetics / Stock Identification Studies:

*Cynoscion regalis*
*Decapterus punctatus*
*Diplodus holbrooki*
*Farfantepenaeus aztecus*
*Farfantepenaeus duorarum*
*Limulus polyphemus*
*Litopenaeus setiferus*
*Micropogonias undulatus*
*Paralichthys lethostigma*

Bottom Mapping:

Abundance, species composition, and site location data provided to SEAMAP Bottom Mapping Program.

Disease Studies:

Shrimp viral testing
*Physteria* screening for *Brevoortia tyrannus* with lesions

Toxicology:

Heavy metals analysis of *Scomberomorus maculatus* tissues
Tetrodotoxin content analysis of *Chilomycterus schoepfi*, *Lagocephalus laevigatus*, and *Sphoeroides maculatus*

Forensics:

Gut content analysis of *Litopenaeus setiferus* and *Farfantepenaeus aztecus*
Various species for standards

Systematics:

Neotype of *Cancer epheliticus* from *Hepatus epheliticus*
*Hepatus epheliticus* for morphological study of crab evolution
Mature females of common decapod crab species
Examples of various decapod crustaceans were donated to Japanese carcinologists
Development of a field key for *Prionotus* spp.
Range verification for *Symphurus plagiusa*

Summary data requested by state agencies:

NC Dept. of Environment, Health, and Natural Resources - Reformatted data from 1989-1996 for *Cynoscion regalis, Leiostomus xanthurus, Menticirrhus americanus, M. saxatilis, Micropogonias undulatus, Paralichthys dentatus, P. lethostigma, Archosargus probatocephalus, Brevoortia tyrannus, Peprilus alepidotus, P. triacanthus, Pomatomus saltatrix*, and *Scomberomorus maculatus* for comparison while validating juvenile abundance indices for the Pamlico Sound Survey.

NCDEHNR / Div. of Marine Fisheries - Abundance data for all species and area swept from all stations in Raleigh, Onslow, and Long Bay (1990 - 1999) for habitat planning.

Georgia DNR - Regional CPUE of *Larimus fasciatus*, *Micropogonias undulatus*, *Leiostomus xanthurus*, *Cynoscion regalis*, and *Cynoscion nothus* by year (1990-1993)

Georgia DNR - *Cynoscion regalis* CPUE by year, season, and strata (1989 - 1995)

Florida DNR - Estimated annual biomass of jellyfish (1992-1995)

Summary data requested by other agencies:

NMSF, Woods Hole - Length frequency data from *Acipencer oxyrhynchus* (1989-1997)

MAFMC - Abundance data (1990-1997) from *Paralichthys dentatus*, *Stenotomus* sp., *Centropristis striata*, *Loligo sp*., *Peprilus triacanthus*, and *Squalus acanthias* to be used for essential fish habitat amendments

NC Fisherman's Association - Abundance and length-frequency data for *Cynoscion regalis* (1987-1995)

Incidental catch of marine turtles:

NMFS Marine Turtle tagging database
Sea Turtle Expert Working Group
Georgia DNR
Florida DNR / Endangered Species Division

## LITERATURE CITED


Anderson, W.W. 1968. Fishes taken during shrimp trawling along the south Atlantic coast of the United States, 1931-35. U.S. Fish and Wildl. Serv., Spec. Sci. Rep. Fish 570, 60 p.

Berrien, P., and D. Finan. 1977. Biological and fisheries data on Spanish mackerel, *Scomberomorus maculatus* (Mitchill). NOAA/NMFS Northeast Fish. Ctr. Tech. Ser. Rep. No. 9, 58 p.

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fish. Bull. 53:1-577.

Blanton, J.O. 1981. Ocean currents along a near shore frontal zone on the continental shelf of the southeastern United States. J. Phys. Ocean. 11(12):1627-1637.

Blanton, J.O., and L.P. Atkinson. 1983. Transport and fate of river discharge on the continental shelf of the southeastern United States. J. Geophys. Res. 88:4730-4738.

Boesch, D.F. 1977. Application of numerical classification in ecological investigations of water pollution. Va. Inst. Mar. Sci. Spec. Sci. Rep. No. 77, 113 p.

Burgess, W.E. 1978. Ephippidae. In: W. Fischer (editor), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. II.

Burukovskii, R.N., and S.K. Bulanenkov. 1971. Pink shrimp: biology and fishing. Atlantic Research Institute of Fisheries and Oceanography, 60 p.

Chao, L.N. 1978. Sciaenidae. In: W. Fischer (ed.) FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. IV.

Collette, B.B. 1978. Scombridae. In: W. Fischer (ed.) FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. IV.

Collette, B.B., and J.L. Russo. 1984. Morphology, systematics, and biology of the Spanish mackerels (*Scomberomorus*, Scombridae) Fishery Bulletin 82(4):545-692.

Collins, M.R., D.J. Schmidt, C.W. Waltz, and J. Pinckney. 1989. Age and growth of king mackerel, *Scomberomorus cavalla*, from the Atlantic coast of the United States. Fish. Bull. 87:49-61.

Dahlberg, M.D. 1972. An ecological study of Georgia coastal fishes. Fish. Bull. 70(2):323-353.

Dawson, C.E. 1958. A study of the biology and life history of the spot, *Leiostomus xanthurus*, Lacepede, with special reference to South Carolina. Contrib. Bears Bluff Lab. No. 28. 48 p.

DeVries, D.A. 1982. Description and catch composition of North Carolina's long haul seine fishery. Proc. Ann. Conf. S.E. Assoc. Fish Wildl. Agen. 34:234-247.

Eldridge, P.J., and W. Waltz. 1977. Observations on the commercial fishery for blue crabs, *Callinectes sapidus*, in estuaries in the southern half of South Carolina. S.C. Mar. Resour. Ctr. Tech. Rep. 21, 35 p.

Flores-Coto, C., and S.M. Warlen. 1993. Spawning time, growth and recruitment of larval spot *Leiostomus xanthurus* into a North Carolina estuary. Fish. Bull. 91(4): p 8-22.

Finucane, J.H., L.A. Collins, H.A. Brusher, and C.H. Saloman. 1986. Reproductive biology of king mackerel, *Scomberomorus cavalla*, from the southeastern United States. Fish. Bull. 84(4):841-850.

Fritzsche, R.A. 1978. Development of fishes of the Mid-Atlantic Bight, Vol. V. Chaetodontidae through Ophidiidae. Fish Wildl. Serv., FWS/OBS-78/12, 340 p.

Gutherz, E.J. 1967. Field guide to the flatfishes of the family Bothidae in the Western North Atlantic. U.S. Fish Wildl. Serv., Circ. 263, pp. 1- 46.

Hayse, J.W. 1987. Feeding habits, age, growth and reproduction of Atlantic spadefish, *Chaetodipterus faber* (Pisces: Ephippidae), in South Carolina. M.S. Thesis. College of Charleston, Charleston, S.C., 59 p.

Hildebrand, S.F., and L.E. Cable. 1930. Development and life history of fourteen teleostean fishes at Beaufort, N.C. Fish. Bull. 46:383-488.

Hildebrand, S.F., and L.E. Cable. 1934. Reproduction and development of whitings of kingfishes, drums, spot, croaker, and weakfishes or sea trouts, Family Sciaenidae, of the Atlantic Coast of the United States. Fish. Bull. 48:41-117.

Hill, B.W. 1984. A description and analysis of the timing of Virginia's Weakfish fishery. Fisheries Analysis Center East, Applied Marine Research Laboratory, Old Dominion University Research Foundation Tech. Rep. 84-8, 94 p.

Horn, M.H. 1970. Systematics and biology of the stromateid fishes of the genus Peprilus. Bull. Mus. Comp. Zool. 149(5):165-262.

Keiser, R.K., Jr. 1976. Species composition, magnitude and utilization of the incidental catch of the South Carolina shrimp fishery. S.C. Mar. Resour. Ctr. Tech. Rep. No.16., 94 p.

Lindner, M.J., and W.W. Anderson. 1956. Growth, migrations, spawning and size distributions of shrimp *Penaeus setiferus*. Fish. Bull. 106(56):553-645.

Low, R., R. Rhodes, E.R. Hens, D. Theiling, E. Wenner, and D. Whitaker. 1987. A profile of the blue crab and its fishery in South Carolina. S.C. Mar. Resour. Ctr. Tech. Rep. No. 66, 37 p.

McClain, C.R., J.A. Yoder, L.P. Atkinson, J.O. Blanton, T.N. Lee, J.J. Singer, and F. Muller-Karger. 1988. Variability of surface pigment concentrations in the South Atlantic Bight. J. Geophys. Res. 93(C9):10675-10697.

Mercer, L.P. 1985. Fishery management plan for the Weakfish (*Cynoscion regalis*) fishery. N.C. Dept. of Nat. Resour., Atl. States Mar. Fish. Comm. Fishery Management Rep. No. 7, 129 p.

Mercer, L.P. 1989. Fishery management plan for spot (*Leiostomus xanthurus*) fishery. N.C. Dept. of Nat. Resour., Atl. States Mar. Fish. Comm. Fishery Management Rep. No. 11, 81 p.

Merriner, J.V. 1976. Aspects of the reproductive biology of the weakfish, *Cynoscion regalis* (Sciaenidae), in North Carolina. Fish. Bull. 74:18-26.

Music, J.L., Jr., and J.R. Pafford. 1984. Population dynamics and life history aspects of major marine sportfishes in Georgia's coastal waters. Georgia Department of Natural Resources, Coastal Resources Division. Contribution Series 38, Brunswick, Georgia.

Pacheco, A.L. 1962. Age and Growth of spot in lower Chesapeake Bay, with notes on distribution and abundance of juveniles in the York river system. Chesapeake Sci. 3:18-28.

Pearson, J.C. 1941. The young of some marine fishes taken in lower Chesapeake Bay, Virginia with special reference to the gray sea trout *Cynoscion regalis* (Bloch and Schneider). Fish. Bull. 50:79-102.

Perez-Farfante, I. 1969. Western Atlantic shrimps of the genus *Penaeus*. Fish. Bull. 67(3):461-591.

Perez-Farfante, I. 1978. Penaeidae. In: W. Fischer (ed.), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. VI.

Perez-Farfante, I., and B. Kensley. 1997. Penaeoid and sergestoid shrimps and prawns of the world: keys and diagnoses for the families and genera. Editions du Muséum, Paris. 233 p.

Pietrafesa, L.J., G.S. Janowitz, and P.A. Wittman. 1985. Physical oceanographic processes in the Carolina Capes. In: L.P. Atkinson, D.W. Menzel, and K.A. Bush (editors), Oceanography of the Southeastern U.S. Continental Shelf, Coastal and Shelf Sci., Vol. II, p. 77-92. AGU, Washington, D.C.

Powell, A.B. and F.J. Schwartz. 1977. Distribution of Paralichthid Flounders (Bothidae: Paralichthys) in North Carolina estuaries. Chesapeake Science 18(4):334-339.

Powell, D. 1975. Age, growth, and reproduction in Florida stocks of Spanish mackerel, *Scomberomorus maculatus*. Fla. Mar. Res. Publ. No. 5, 21 p.

Powles, H., and B.W. Stender. 1978. Taxonomic data on the early life history stages of Sciaenidae of the South Atlantic Bight of the United States. S.C. Mar. Resour. Ctr. Tech. Rep. No. 31, 62 p.

Randall, J.E. 1978. Sparidae. In: Fischer, W. (ed). FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. V.

Renfro, W.C., and H.A. Brusher. 1982. Seasonal abundance, size distribution, and spawning of three shrimps (*Penaeus aztecus*, *P. setiferus*, and *P. duorarum*) in the northwestern Gulf of Mexico, 1961-1962. U.S. Dept. of Comm., NOAA, NMFS, NOAA Tech. Memorandum NMFS-SEFC-94, 24 p.

Robins, Richard C., and G. Carleton Ray. 1986. A field guide to Atlantic coast fishes of North America. (The Peterson field guide series; 32). Boston, Mass. Houghton Mifflin Company.

Ross, S.W. 1988. Age, growth, and mortality of Atlantic Croaker in North Carolina, with comments on population dynamics. Trans. Am. Fish. Soc. 117:461-473.

Schmidt, D.J., M.R. Collins, and D.M. Wyanski. 1993. Age, growth, maturity, and spawning of Spanish mackerel, *Scomberomorus maculatus* (Mitchell), from the Atlantic Coast of the southeastern United States. Fish. Bull. 91:526-533.

Smith, C.L. 1978. Serranidae. In: W. Fischer (ed.), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. IV.

Smith, J.W. 1999. Distribution of Atlantic menhaden, *Brevoortia tyrannus*, purse-seine sets and catches from southern New England to North Carolina, 1985-1996. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 144, 22 p.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. W. H. Freeman and Co., New York.

South Atlantic Fishery Management Council. 1981. Profile of the penaeid shrimp fishery in the south Atlantic. SAFMC, Charleston, S.C.

Stender, B.W., and C.A. Barans. 1994. Comparison of the catch from tongue and two-seam shrimp nets off South Carolina. N. Am. J. Fish. Manage. 14:178-195.

Sutter, F.C., III, R.O. Williams, and M.F. Godcharles. 1991. Movement patterns and stock affinities of king mackerel in the southeastern United States. Fish. Bull. 89:315-324.

Thomas, D.L. 1971. The early life history and ecology of six species of drum (Sciaenidae) in the lower Delaware River, a brackish tidal estuary. (An ecological study of the Delaware River in the vicinity of Artificial Island, Pt. III). Ichthyological Assoc. Bull. No. 3. 247 p.

Vergara, R. 1978. Stromateidae. In: W. Fischer (editor), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. Vol. V.

Warlen, S.M. 1982. Age and growth of larvae and spawning of Atlantic croaker in North Carolina. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agen. 34:204-214.

Welsh, W.W., and C.M. Breder. 1923. Contributions to life histories of Sciaenidae of the eastern United States coast. Fish. Bull. 39: 141-201.

Wenner, C.A., and G.R. Sedberry. 1989. Species composition, distribution, and relative abundance of fishes in the coastal habitat of the Southeastern United States. U.S. Dept. Comm. NOAA Tech. Rep., NMFS-SSRF-79, 49 p.

Whitehead, P.J.P. 1978. Clupeidae. In: W. Fischer (editor), FAO species identification sheets for fishery purposes. West Central Atlantic (fishing area 31). Food and Agricultural Organization of the U.N. 6 Volumes, pag. var.

Williams, A.B. 1984. Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press, Washington, D.C. 550 p.

Appendix 1. Number of individuals and biomass (kg) for all species collected (1990 -1999). Abundance and biomass for inner strata only are indicated in parentheses.

| Rank | Species Name | Total Number | | Total Weight | |
|---|---|---|---|---|---|
| 1 | LEIOSTOMUS XANTHURUS | 661229 | (611710) | 41930.744 | (37585.314) |
| 2 | MICROPOGONIAS UNDULATUS | 613038 | (552994) | 36364.569 | (31605.011) |
| 3 | CHLOROSCOMBRUS CHRYSURUS | 170683 | (160032) | 3322.921 | (2877.388) |
| 4 | STENOTOMUS SP. | 153528 | (85321) | 7361.754 | (4320.667) |
| 5 | ANCHOA HEPSETUS | 150017 | (143232) | 1059.504 | (1011.178) |
| 6 | LITOPENAEUS SETIFERUS | 122992 | (119926) | 3085.300 | (2994.377) |
| 7 | LAGODON RHOMBOIDES | 114014 | (107928) | 6389.501 | (5921.835) |
| 8 | LOLLIGUNCULA BREVIS | 97319 | (92167) | 1020.061 | (963.312) |
| 9 | STELLIFER LANCEOLATUS | 88446 | (86402) | 1357.290 | (1300.157) |
| 10 | LARIMUS FASCIATUS | 79760 | (62140) | 5050.079 | (3272.602) |
| 11 | CYNOSCION NOTHUS | 78797 | (68501) | 3266.822 | (2548.474) |
| 12 | LOLIGO SP. | 78768 | (30157) | 1074.910 | (454.116) |
| 13 | MENTICIRRHUS AMERICANUS | 73248 | (67381) | 7520.952 | (6706.738) |
| 14 | OPISTHONEMA OGLINUM | 70465 | (65605) | 1219.193 | (1119.180) |
| 15 | SYNODUS FOETENS | 66450 | (40981) | 4937.699 | (3059.449) |
| 16 | CYNOSCION REGALIS | 55937 | (53412) | 4051.471 | (3722.234) |
| 17 | SELENE SETAPINNIS | 54157 | (53517) | 499.048 | (479.657) |
| 18 | ANCHOA MITCHILLI | 52418 | (50856) | 70.475 | (67.100) |
| 19 | PRIONOTUS CAROLINUS | 48139 | (32741) | 635.068 | (405.286) |
| 20 | PEPRILUS TRIACANTHUS | 45357 | (35383) | 1311.789 | (924.618) |
| 21 | PEPRILUS ALEPIDOTUS | 40836 | (39225) | 2049.168 | (1952.284) |
| 22 | OVALIPES STEPHENSONI | 39211 | (29674) | 347.246 | (240.095) |
| 23 | FARFANTEPENAEUS AZTECUS | 37790 | (36489) | 613.268 | (590.446) |
| 24 | TRICHIURUS LEPTURUS | 32926 | (31876) | 1831.371 | (1775.897) |
| 25 | PORTUNUS GIBBESII | 32444 | (30141) | 253.853 | (227.222) |
| 26 | ARIUS FELIS | 31501 | (31267) | 2121.887 | (2080.396) |
| 27 | ORTHOPRISTIS CHRYSOPTERA | 30521 | (23490) | 2029.941 | (1578.067) |

| | | | | | |
|---|---|---|---|---|---|
| 28 | CALLINECTES SIMILIS | 23191 | (22101) | 336.180 | (309.277) |
| 29 | CHAETODIPTERUS FABER | 18568 | (16968) | 1670.762 | (1541.367) |
| 30 | UROPHYCIS REGIUS | 18415 | (17487) | 503.751 | (485.889) |
| 31 | LIBINIA DUBIA | 18180 | (17967) | 127.037 | (125.165) |
| 32 | BREVOORTIA TYRANNUS | 16828 | (16634) | 456.895 | (444.333) |
| 33 | BAIRDIELLA CHRYSOURA | 15954 | (15273) | 779.542 | (741.825) |
| 34 | SCOMBEROMORUS MACULATUS | 13302 | (12762) | 1547.603 | (1441.300) |
| 35 | SYMPHURUS PLAGIUSA | 13073 | (11889) | 447.505 | (407.625) |
| 36 | POMATOMUS SALTATRIX | 12360 | (12161) | 1213.298 | (1185.371) |
| 37 | TRINECTES MACULATUS | 10525 | (10405) | 313.373 | (309.055) |
| 38 | ANCHOA LYOLEPIS | 10332 | (9465) | 22.358 | (20.921) |
| 39 | SCOPHTHALMUS AQUOSUS | 9995 | (9580) | 254.551 | (236.304) |
| 40 | SQUILLA EMPUSA | 9520 | (8377) | 161.089 | (140.399) |
| 41 | ETROPUS CROSSOTUS | 8477 | (6732) | 168.339 | (124.582) |
| 42 | SPHOEROIDES MACULATUS | 8234 | (7285) | 993.649 | (910.289) |
| 43 | PRIONOTUS SCITULUS | 8055 | (5630) | 260.619 | (168.990) |
| 44 | ARENAEUS CRIBRARIUS | 8034 | (7888) | 319.485 | (312.565) |
| 45 | FARFANTEPENAEUS DUORARUM | 8027 | (6852) | 127.706 | (108.081) |
| 46 | OVALIPES OCELLATUS | 7902 | (7255) | 136.439 | (124.020) |
| 47 | PORTUNUS SPINIMANUS | 7548 | (6654) | 171.328 | (147.694) |
| 48 | CITHARICHTHYS MACROPS | 7498 | (6076) | 122.429 | (94.317) |
| 49 | XIPHOPENAEUS KROYERI | 7486 | (7474) | 43.900 | (43.894) |
| 50 | SCOMBEROMORUS CAVALLA | 7177 | (6604) | 490.094 | (416.366) |
| 51 | DECAPTERUS PUNCTATUS | 6478 | (2189) | 233.230 | (115.550) |
| 52 | RHIZOPRIONODON TERRAENOVAE | 6320 | (6009) | 4602.986 | (3937.327) |
| 53 | EUCINOSTOMUS SP. | 5649 | (4588) | 93.775 | (72.790) |
| 54 | SQUILLA NEGLECTA | 5013 | (4184) | 59.300 | (48.692) |
| 55 | ANCYLOPSETTA QUADROCELLATA | 4982 | (3600) | 262.147 | (183.859) |
| 56 | CALLINECTES SAPIDUS | 4770 | (4615) | 702.205 | (683.316) |
| 57 | PARALICHTHYS DENTATUS | 4161 | (3856) | 675.913 | (601.329) |
| 58 | SPHYRAENA GUACHANCHO | 4154 | (3550) | 317.433 | (237.442) |

| | | | | | |
|---|---|---|---|---|---|
| 59 | SARDINELLA AURITA | 3989 | (2391) | 97.337 | (34.306) |
| 60 | SELENE VOMER | 3977 | (3923) | 114.522 | (112.753) |
| 61 | BAGRE MARINUS | 3808 | (3778) | 211.084 | (208.548) |
| 62 | DASYATIS SAYI | 3586 | (3408) | 5806.302 | (5574.637) |
| 63 | PAGURUS POLLICARIS | 3451 | (3336) | 92.672 | (89.952) |
| 64 | RAJA EGLANTERIA | 3218 | (2808) | 2651.487 | (2290.507) |
| 65 | PRIONOTUS EVOLANS | 3206 | (2908) | 146.105 | (108.844) |
| 66 | MUSTELUS CANIS | 3061 | (3061) | 2551.202 | (2551.202) |
| 67 | CARANX CRYSOS | 2870 | (2476) | 226.922 | (194.291) |
| 68 | RHINOPTERA BONASUS | 2808 | (2320) | 20628.142 | (17071.569) |
| 69 | DIPLECTRUM FORMOSUM | 2427 | (208) | 135.747 | (11.630) |
| 70 | MYLIOBATIS FREMINVILLEI | 2378 | (2316) | 15946.842 | (15835.444) |
| 71 | LIBINIA EMARGINATA | 2270 | (2106) | 92.469 | (85.360) |
| 72 | CENTROPRISTIS PHILADELPHICA | 2252 | (1908) | 95.539 | (80.486) |
| 73 | ETROPUS CYCLOSQUAMUS | 2240 | (1418) | 21.724 | (13.978) |
| 74 | HEPATUS EPHELITICUS | 2212 | (1872) | 62.225 | (53.580) |
| 75 | PRIONOTUS RUBIO | 2188 | (1074) | 78.622 | (24.632) |
| 76 | SPHYRNA TIBURO | 2063 | (1809) | 3624.362 | (3233.147) |
| 77 | PRIONOTUS TRIBULUS | 1955 | (1756) | 102.556 | (80.915) |
| 78 | CENTROPRISTIS STRIATA | 1780 | (1484) | 140.720 | (107.767) |
| 79 | GYMNURA MICRURA | 1776 | (1731) | 1684.427 | (1612.726) |
| 80 | ETRUMEUS TERES | 1727 | (915) | 3.974 | (2.141) |
| 81 | SYACIUM PAPILLOSUM | 1575 | (304) | 105.132 | (23.438) |
| 82 | MENTICIRRHUS LITTORALIS | 1545 | (1517) | 245.026 | (239.559) |
| 83 | CHILOMYCTERUS SCHOEPFI | 1538 | (1344) | 362.962 | (311.969) |
| 84 | HARENGULA JAGUANA | 1419 | (1406) | 26.947 | (26.589) |
| 85 | TRACHURUS LATHAMI | 1355 | (53) | 7.983 | (0.637) |
| 86 | RIMAPENAEUS CONSTRICTUS | 1321 | (1260) | 4.116 | (3.819) |
| 87 | MONACANTHUS HISPIDUS | 1318 | (986) | 41.559 | (31.722) |
| 88 | ALOSA AESTIVALIS | 1293 | (1258) | 31.258 | (30.231) |
| 89 | MENTICIRRHUS SAXATILIS | 1280 | (1020) | 172.962 | (129.525) |

| | | | | | |
|---|---|---|---|---|---|
| 90 | HAEMULON AUROLINEATUM | 1128 | (513) | 106.423 | (44.714) |
| 91 | UPENEUS PARVUS | 880 | (56) | 40.299 | (0.799) |
| 92 | PERSEPHONA MEDITERRANEA | 873 | (743) | 11.442 | (9.917) |
| 93 | CALLINECTES ORNATUS | 855 | (844) | 11.738 | (11.478) |
| 94 | PAGURUS LONGICARPUS | 642 | (569) | 0.347 | (0.320) |
| 95 | TRACHINOTUS CAROLINUS | 626 | (619) | 114.519 | (112.646) |
| 96 | HEMIPTERONOTUS NOVACULA | 591 | (8) | 30.194 | (0.264) |
| 97 | NEOPANOPE SAYI | 540 | (516) | 2.451 | (2.414) |
| 98 | CITHARICHTHYS SPILOPTERUS | 527 | (497) | 8.081 | (7.585) |
| 99 | CARANX HIPPOS | 521 | (510) | 40.652 | (39.789) |
| 100 | PARALICHTHYS LETHOSTIGMA | 517 | (489) | 184.907 | (172.402) |
| 101 | UROPHYCIS FLORIDANUS | 508 | (339) | 26.545 | (18.817) |
| 102 | BREVOORTIA SMITHI | 496 | (436) | 78.460 | (66.278) |
| 103 | PILUMNUS SAYI | 455 | (305) | 2.064 | (1.421) |
| 104 | DASYATIS SABINA | 402 | (387) | 151.617 | (147.993) |
| 105 | CALAPPA FLAMMEA | 376 | (243) | 66.655 | (44.264) |
| 106 | ACANTHOSTRACION QUADRICORNIS | 345 | (211) | 123.542 | (71.951) |
| 107 | CALAMUS LEUCOSTEUS | 341 | (233) | 130.840 | (92.769) |
| 108 | MENIPPE MERCENARIA | 292 | (282) | 19.148 | (18.491) |
| 109 | CANCER IRRORATUS | 278 | (269) | 1.417 | (1.362) |
| 110 | ECHENEIS NAUCRATES | 272 | (235) | 55.814 | (43.743) |
| 111 | PARALICHTHYS ALBIGUTTA | 265 | (163) | 74.511 | (38.445) |
| 112 | ALUTERUS SCHOEPFI | 264 | (184) | 127.438 | (47.638) |
| 113 | ARCHOSARGUS PROBATOCEPHALUS | 259 | (252) | 646.723 | (634.393) |
| 114 | DASYATIS AMERICANA | 249 | (223) | 707.806 | (647.066) |
| 115 | CHAETODON OCELLATUS | 245 | (241) | 3.833 | (3.755) |
| 116 | SCOMBER JAPONICUS | 223 | (108) | 12.187 | (5.443) |
| 117 | HIPPOCAMPUS ERECTUS | 215 | (120) | 2.154 | (1.143) |
| 118 | SICYONIA BREVIROSTRIS | 211 | (65) | 2.324 | (0.652) |
| 119 | DASYATIS CENTROURA | 207 | (154) | 7980.764 | (4199.364) |
| 120 | PORCELLANA SIGSBEIANA | 202 | (166) | 0.240 | (0.197) |

| | | | | | |
|---|---|---|---|---|---|
| 121 | DROMIDIA ANTILLENSIS | 191 | (23) | 5.057 | (0.648) |
| 122 | ALECTIS CILIARIUS | 174 | (165) | 9.836 | (9.706) |
| 123 | RACHYCENTRON CANADUM | 173 | (111) | 222.918 | (133.566) |
| 124 | LUTJANUS SYNAGRIS | 171 | (164) | 5.633 | (5.505) |
| 125 | TRACHINOCEPHALUS MYOPS | 168 | (5) | 4.725 | (0.340) |
| 126 | OCTOPUS VULGARIS | 156 | (69) | 25.069 | (16.831) |
| 127 | MOBULA HYPOSTOMA | 155 | (155) | 2742.800 | (2742.800) |
| 128 | BALISTES CAPRISCUS | 151 | (93) | 29.338 | (22.492) |
| 129 | UMBRINA COROIDES | 145 | (145) | 5.840 | (5.840) |
| 130 | MUGIL CUREMA | 143 | (143) | 4.327 | (4.327) |
| 131 | GYMNURA ALTAVELA | 133 | (86) | 2973.551 | (2077.540) |
| 132 | LAGOCEPHALUS LAEVIGATUS | 120 | (60) | 4.656 | (2.496) |
| 133 | SELAR CRUMENOPHTHALMUS | 118 | (4) | 5.900 | (0.152) |
| 134 | DIPLODUS HOLBROOKI | 118 | (100) | 15.361 | (14.141) |
| 135 | SERIOLA ZONATA | 112 | (88) | 18.331 | (16.388) |
| 136 | PARALICHTHYS SQUAMILENTUS | 107 | (107) | 3.584 | (3.584) |
| 137 | ARIOMMA REGULUS | 103 | (34) | 1.392 | (0.291) |
| 138 | AETOBATUS ARINARI | 101 | (99) | 1346.450 | (1274.510) |
| 139 | NARCINE BRASILIENSIS | 98 | (96) | 36.223 | (35.003) |
| 140 | RHINOBATOS LENTIGINOSUS | 93 | (90) | 240.235 | (238.279) |
| 141 | HYPLEUROCHILUS GEMINATUS | 93 | (81) | 0.183 | (0.141) |
| 142 | PETROLISTHES GALATHINUS | 85 | (82) | 0.094 | (0.090) |
| 143 | PAGURUS IMPRESSUS | 85 | (22) | 3.700 | (1.408) |
| 144 | CARCHARHINUS ACRONOTUS | 75 | (67) | 250.914 | (210.120) |
| 145 | OPSANUS TAU | 68 | (66) | 12.468 | (12.446) |
| 146 | UROPHYCIS EARLLI | 63 | (45) | 5.441 | (4.577) |
| 147 | POGONIAS CROMIS | 60 | (60) | 54.872 | (54.872) |
| 148 | SYNGNATHUS LOUISIANAE | 59 | (51) | 0.689 | (0.575) |
| 149 | ENGRAULIS EURYSTOLE | 56 | (56) | 0.077 | (0.077) |
| 150 | SQUALUS ACANTHIAS | 55 | (55) | 102.056 | (102.056) |
| 151 | SCORPAENA BRASILIENSIS | 54 | (41) | 3.148 | (2.663) |

| | | | | | |
|---|---|---|---|---|---|
| 152 | LYSMATA WURDEMANNI | 54 | (51) | 0.488 | (0.485) |
| 153 | PETROCHIRUS DIOGENES | 54 | (20) | 11.367 | (6.808) |
| 154 | EQUETUS UMBROSUS | 52 | (52) | 1.273 | (1.273) |
| 155 | OGCOCEPHALUS ROSTELLUM | 49 | (45) | 1.743 | (0.934) |
| 156 | PORTUNUS SAYI | 48 | (41) | 0.275 | (0.207) |
| 157 | OLIGOPLITES SAURUS | 47 | (46) | 3.847 | (3.770) |
| 158 | PORICHTHYS PLECTRODON | 46 | (41) | 2.501 | (2.187) |
| 159 | OPHIDION MARGINATA | 44 | (43) | 2.026 | (1.985) |
| 160 | PAGURUS ANNULIPES | 42 | (41) | 0.011 | (0.010) |
| 161 | PODOCHELA RIISEI | 39 | (16) | 0.114 | (0.057) |
| 162 | HYPSOBLENNIUS HENTZI | 38 | (38) | 0.446 | (0.446) |
| 163 | CARCHARHINUS PLUMBEUS | 37 | (36) | 184.565 | (178.005) |
| 164 | BOTHUS ROBINSI | 35 | (3) | 0.540 | (0.050) |
| 165 | ALBUNEA PARETII | 35 | (35) | 0.190 | (0.190) |
| 166 | HALICHOERES CAUDALIS | 34 | (1) | 1.643 | (0.041) |
| 167 | FISTULARIA TABACARIA | 33 | (27) | 1.010 | (0.618) |
| 168 | OGCOCEPHALUS CUBIFRONS | 31 | (21) | 4.160 | (0.351) |
| 169 | SCORPAENA CALCARATA | 28 | (2) | 0.448 | (0.039) |
| 170 | SICYONIA LAEVIGATA | 28 | (0) | 0.145 | (0.000) |
| 171 | SPHYRNA LEWINI | 27 | (27) | 49.121 | (49.121) |
| 172 | ELOPS SAURUS | 26 | (26) | 3.449 | (3.449) |
| 173 | HALICHOERES BIVITTATA | 24 | (1) | 1.149 | (0.075) |
| 174 | GOBIOSOMA BOSCI | 24 | (16) | 0.044 | (0.033) |
| 175 | PRIONOTUS OPHRYAS | 24 | (11) | 0.445 | (0.247) |
| 176 | PORCELLANA SAYANA | 24 | (23) | 0.038 | (0.037) |
| 177 | CARCHARHINUS OBSCURUS | 23 | (22) | 116.024 | (109.494) |
| 178 | PRIACANTHUS CRUENTATUS | 23 | (14) | 0.315 | (0.179) |
| 179 | GYMNACHIRUS MELAS | 21 | (18) | 0.578 | (0.492) |
| 180 | LUTJANUS GRISEUS | 20 | (20) | 0.583 | (0.583) |
| 181 | ASTROSCOPUS Y-GRAECUM | 20 | (20) | 2.962 | (2.962) |
| 182 | CRANGON SEPTEMSPINOSA | 20 | (20) | 0.368 | (0.368) |

| | | | | | |
|---|---|---|---|---|---|
| 183 | ODONTASPIS TAURUS | 19 | (17) | 1296.130 | (1026.130) |
| 184 | PODOCHELA SIDNEYI | 19 | (15) | 0.053 | (0.043) |
| 185 | MITHRAX HISPIDUS | 19 | (0) | 0.058 | (0.000) |
| 186 | PORTUNUS FLORIDANUS | 19 | (0) | 0.050 | (0.000) |
| 187 | MITHRAX PLEURACANTHUS | 18 | (0) | 0.317 | (0.000) |
| 188 | PRIACANTHUS ARENATUS | 16 | (6) | 0.542 | (0.404) |
| 189 | CRONIUS RUBER | 16 | (16) | 0.299 | (0.299) |
| 190 | CARCHARHINUS BREVIPINNA | 15 | (14) | 266.585 | (263.585) |
| 191 | SYNALPHEUS FRITZMUELLERI | 15 | (10) | 0.017 | (0.012) |
| 192 | CARANX BARTHOLOMAEI | 14 | (14) | 0.139 | (0.139) |
| 193 | METOPORHAPHIS CALCARATA | 14 | (0) | 0.017 | (0.000) |
| 194 | PELIA MUTICA | 14 | (12) | 0.011 | (0.008) |
| 195 | MACROCOELOMA CAMPTOCERUM | 14 | (3) | 0.059 | (0.017) |
| 196 | MENIDIA MENIDIA | 13 | (13) | 0.060 | (0.060) |
| 197 | OPHIDION GRAYI | 13 | (8) | 0.969 | (0.617) |
| 198 | PANOPEUS HERBSTII | 12 | (12) | 0.018 | (0.018) |
| 199 | CARCHARHINUS LIMBATUS | 11 | (11) | 68.820 | (68.820) |
| 200 | MEMBRAS MARTINICA | 11 | (11) | 0.057 | (0.057) |
| 201 | HYPOCONCHA SPINOSISSIMA | 11 | (9) | 0.242 | (0.092) |
| 202 | SERRANUS SUBLIGARIUS | 10 | (0) | 0.072 | (0.000) |
| 203 | ASTROSCOPUS GUTTATUS | 10 | (10) | 0.701 | (0.701) |
| 204 | LUTJANUS CAMPECHANUS | 9 | (2) | 0.252 | (0.056) |
| 205 | CYNOSCION NEBULOSUS | 9 | (9) | 1.602 | (1.602) |
| 206 | DACTYLOPTERUS VOLITANS | 9 | (3) | 0.325 | (0.198) |
| 207 | ALOPIAS VULPINUS | 9 | (9) | 232.500 | (232.500) |
| 208 | PETROLISTHES ARMATUS | 9 | (9) | 0.018 | (0.018) |
| 209 | OPHICHTHUS GOMESI | 8 | (8) | 1.389 | (1.389) |
| 210 | HAEMULON PLUMIERI | 8 | (2) | 0.991 | (0.954) |
| 211 | PRIONOTUS ROSEUS | 8 | (0) | 0.230 | (0.000) |
| 212 | DOROSOMA PETENENSE | 8 | (8) | 0.298 | (0.298) |
| 213 | HYPOCONCHA ARCUATA | 8 | (7) | 0.080 | (0.061) |

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|---|---|---|---|---|---|
| 214 | PILUMNUS FLORIDANUS | 8 | (8) | 0.004 | (0.004) |
| 215 | ACIPENSER OXYRHYNCHUS | 7 | (7) | 52.670 | (52.670) |
| 216 | OPHICHTHUS OCELLATUS | 7 | (6) | 0.971 | (0.961) |
| 217 | LUTJANUS ANALIS | 7 | (7) | 0.278 | (0.278) |
| 218 | SCYLLARUS CHACEI | 7 | (6) | 0.058 | (0.053) |
| 219 | PARTHENOPE GRANULATA | 7 | (1) | 0.044 | (0.001) |
| 220 | MYCTEROPERCA MICROLEPIS | 6 | (3) | 0.591 | (0.430) |
| 221 | SPHOEROIDES DORSALIS | 6 | (0) | 0.206 | (0.000) |
| 222 | CALAPPA SULCATA | 6 | (2) | 0.218 | (0.040) |
| 223 | CARCHARHINUS ISODON | 5 | (5) | 21.930 | (21.930) |
| 224 | SQUATINA DUMERIL | 5 | (5) | 49.730 | (49.730) |
| 225 | GOBIESOX STRUMOSUS | 5 | (4) | 0.021 | (0.020) |
| 226 | SYNGNATHUS FUSCUS | 5 | (5) | 0.046 | (0.046) |
| 227 | HYPORHAMPHUS MEEKI | 5 | (2) | 0.029 | (0.011) |
| 228 | DIAPTERUS OLISTHOSTOMUS | 5 | (5) | 0.262 | (0.262) |
| 229 | SYNALPHEUS TOWNSENDI | 5 | (5) | 0.017 | (0.017) |
| 230 | RHITHROPANOPEUS HARRISII | 5 | (4) | 0.007 | (0.006) |
| 231 | LYSIOSQUILLA SCABRICAUDA | 5 | (4) | 0.384 | (0.290) |
| 232 | CONGER OCEANICUS | 4 | (4) | 0.769 | (0.769) |
| 233 | SERIOLA DUMERILI | 4 | (1) | 40.087 | (0.087) |
| 234 | EQUETUS LANCEOLATUS | 4 | (2) | 0.028 | (0.011) |
| 235 | SCIAENOPS OCELLATUS | 4 | (3) | 38.020 | (30.220) |
| 236 | LACHNOLAIMUS MAXIMUS | 4 | (0) | 0.104 | (0.000) |
| 237 | MUGIL CEPHALUS | 4 | (4) | 0.446 | (0.446) |
| 238 | HEXAPANOPEUS ANGUSTIFRONS | 4 | (4) | 0.003 | (0.003) |
| 239 | MITHRAX FORCEPS | 4 | (0) | 0.009 | (0.000) |
| 240 | PENAEUS VANNAMEI | 4 | (4) | 0.051 | (0.051) |
| 241 | ALOSA SAPIDISSIMA | 3 | (2) | 0.145 | (0.119) |
| 242 | OGCOCEPHALUS PARVUS | 3 | (2) | 0.832 | (0.473) |
| 243 | CENTROPRISTIS OCYURUS | 3 | (0) | 0.034 | (0.000) |
| 244 | TAUTOGA ONITIS | 3 | (2) | 0.181 | (0.142) |

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|---|---|---|---|---|---|
| 245 | GOBIONELLUS HASTATUS | 3 | (3) | 0.040 | (0.040) |
| 246 | SCOMBER SCOMBRUS | 3 | (3) | 0.014 | (0.014) |
| 247 | SPHOEROIDES NEPHELUS | 3 | (3) | 0.075 | (0.075) |
| 248 | SPHOEROIDES SPENGLERI | 3 | (1) | 0.059 | (0.006) |
| 249 | RYPTICUS MACULATUS | 3 | (2) | 0.752 | (0.052) |
| 250 | URASPIS SECUNDA | 3 | (3) | 0.260 | (0.260) |
| 251 | PSEUDOMEDAEUS AGASSIZII | 3 | (1) | 0.004 | (0.001) |
| 252 | SCYLLARUS AMERICANUS | 3 | (3) | 0.028 | (0.028) |
| 253 | HISTRIO HISTRIO | 2 | (2) | 0.040 | (0.040) |
| 254 | PRISTIGENYS ALTUS | 2 | (2) | 0.040 | (0.040) |
| 255 | CARANX LATUS | 2 | (1) | 0.290 | (0.140) |
| 256 | CARANX RUBER | 2 | (2) | 0.037 | (0.037) |
| 257 | DECAPTERUS MACARELLUS | 2 | (0) | 0.079 | (0.000) |
| 258 | LOBOTES SURINAMENSIS | 2 | (2) | 3.000 | (3.000) |
| 259 | SCOMBEROMORUS REGALIS | 2 | (2) | 0.211 | (0.211) |
| 260 | CYCLOPSETTA FIMBRIATA | 2 | (0) | 0.121 | (0.000) |
| 261 | SYMPHURUS UROSPILUS | 2 | (0) | 0.054 | (0.000) |
| 262 | OPHIDION WELSHI | 2 | (1) | 0.016 | (0.007) |
| 263 | MEGALOPS ATLANTICUS | 2 | (2) | 50.430 | (50.430) |
| 264 | ALPHEUS HETEROCHAELIS | 2 | (2) | 0.006 | (0.006) |
| 265 | EXHIPPOLYSMATA OPLOPHOROIDES | 2 | (2) | 0.006 | (0.006) |
| 266 | DARDANUS INSIGNIS | 2 | (0) | 0.019 | (0.000) |
| 267 | CALAPPA ANGUSTA | 2 | (2) | 0.056 | (0.056) |
| 268 | MITHRAX SPINOSISSIMUS | 2 | (0) | 0.008 | (0.000) |
| 269 | MACROCOELOMA TRISPINOSUM | 2 | (0) | 0.036 | (0.000) |
| 270 | COELOCERUS SPINOSUS | 2 | (1) | 0.008 | (0.002) |
| 271 | PAGURUS SP. | 2 | (0) | 0.008 | (0.000) |
| 272 | SPEOCARCINUS CAROLINENSIS | 2 | (2) | 0.044 | (0.044) |
| 273 | PAGURISTES HUMMI | 2 | (1) | 0.007 | (0.002) |
| 274 | GINGLYMOSTOMA CIRRATUM | 1 | (1) | 50.000 | (50.000) |
| 275 | CARCHARHINUS LEUCAS | 1 | (1) | 100.000 | (100.000) |

| | | | | | |
|---|---|---|---|---|---|
| 276 | MYROPHIS PUNCTATUS | 1 | (1) | 0.003 | (0.003) |
| 277 | LOPHIUS AMERICANUS | 1 | (1) | 1.140 | (1.140) |
| 278 | ANTENNARIUS OCELLATUS | 1 | (1) | 0.179 | (0.179) |
| 279 | OGCOCEPHALUS RADIATUS | 1 | (0) | 0.495 | (0.000) |
| 280 | ABLENNES HIANS | 1 | (1) | 0.014 | (0.014) |
| 281 | MENIDIA BERYLLINA | 1 | (1) | 0.005 | (0.005) |
| 282 | SYNGNATHUS SPRINGERI | 1 | (0) | 0.010 | (0.000) |
| 283 | EPINEPHELUS MORIO | 1 | (0) | 0.077 | (0.000) |
| 284 | REMORA REMORA | 1 | (1) | 0.274 | (0.274) |
| 285 | HEMICARANX AMBLYRHYNCHUS | 1 | (1) | 0.005 | (0.005) |
| 286 | TRACHINOTUS FALCATUS | 1 | (1) | 0.150 | (0.150) |
| 287 | HAEMULON SCIURUS | 1 | (1) | 0.103 | (0.103) |
| 288 | HOLACANTHUS ISABELITA | 1 | (1) | 0.159 | (0.159) |
| 289 | SPHYRAENA BARRACUDA | 1 | (1) | 7.370 | (7.370) |
| 290 | PARABLENNIUS MARMOREUS | 1 | (1) | 0.001 | (0.001) |
| 291 | ACANTHURUS CHIRURGUS | 1 | (0) | 0.020 | (0.000) |
| 292 | ALUTERUS HEUDELOTI | 1 | (0) | 0.280 | (0.000) |
| 293 | ALUTERUS MONOCEROS | 1 | (0) | 1.294 | (0.000) |
| 294 | GOBIOSOMA GINSBURGI | 1 | (1) | 0.002 | (0.002) |
| 295 | PSENES PELLUCIDUS | 1 | (1) | 0.132 | (0.132) |
| 296 | ACHIRUS LINEATUS | 1 | (1) | 0.016 | (0.016) |
| 297 | ANTENNARIOUS RADIOSUS | 1 | (0) | 0.017 | (0.000) |
| 298 | OPSANUS PARDUS | 1 | (0) | 0.045 | (0.000) |
| 299 | OGCOCEPHALUS NASUTUS | 1 | (0) | 0.098 | (0.000) |
| 300 | LABRISOMUS NUCHIPINNIS | 1 | (1) | 0.039 | (0.039) |
| 301 | STRONGYLURA NOTATA | 1 | (1) | 0.053 | (0.053) |
| 302 | GOBIOSOMA ROBUSTUM | 1 | (0) | 0.004 | (0.000) |
| 303 | ALPHEUS FORMOSUS | 1 | (0) | 0.005 | (0.000) |
| 304 | SYNALPHEUS MINUS | 1 | (1) | 0.001 | (0.001) |
| 305 | EUCERAMUS PRAELONGUS | 1 | (1) | 0.001 | (0.001) |
| 306 | CLIBANARIUS VITTATUS | 1 | (1) | 0.001 | (0.001) |

| | | | | | |
|---|---|---|---|---|---|
| 307 | HYPOCONCHA SABULOSA | 1 | (0) | 0.003 | (0.000) |
| 308 | LOBOPILUMNUS AGASSIZII | 1 | (1) | 0.001 | (0.001) |
| 309 | GLYPTOXANTHUS EROSUS | 1 | (0) | 0.001 | (0.000) |
| 310 | MICROPANOPE NUTTINGI | 1 | (1) | 0.001 | (0.001) |
| 311 | PINNIXA CHAETOPTERANA | 1 | (1) | 0.001 | (0.001) |
| 312 | COLLODES TRISPINOSUS | 1 | (0) | 0.006 | (0.000) |
| 313 | STENORHYNCHUS SETICORNIS | 1 | (0) | 0.002 | (0.000) |
| 314 | TYCHE EMARGINATA | 1 | (0) | 0.003 | (0.000) |
| 315 | MICROPHRYS ANTILLENSIS | 1 | (0) | 0.004 | (0.000) |
| 316 | DOMECIA ACANTHOPHORA | 1 | (0) | 0.001 | (0.000) |
| 317 | ROCHINIA CRASSA | 1 | (1) | 0.005 | (0.005) |
| 318 | PINNAXODES FLORIDENSIS | 1 | (1) | 0.001 | (0.001) |
| 319 | SYNALPHEUS SP. | 1 | (0) | 0.001 | (0.000) |
| 320 | CALAPPA GALLUS | 1 | (0) | 0.007 | (0.000) |
| 321 | PINNIXA FLORIDANA | 1 | (0) | 0.001 | (0.000) |
| 322 | CALLINECTES LARVATUS | 1 | (1) | 0.030 | (0.030) |

Appendix 2. Summary of effort (number of trawl tows), diversity (number of species), abundance (number of individuals), biomass (kg), density of individuals (number/ha), and density of biomass (kg/ha), excluding miscellaneous invertebrates and algae, by region and season from inner strata.

| | | | | | DENSITY | |
|---|---|---|---|---|---|---|
| | **TOWS** | **SPECIES** | **INDIVIDUALS** | **BIOMASS** | **INDIVIDUALS** | **BIOMASS** |
| **REGION** | | | | | | |
| RALEIGH BAY | 120 | 147 | 329,865 | 27,462 | 717.7 | 59.7 |
| ONSLOW BAY | 298 | 184 | 512,281 | 35,961 | 447.0 | 31.4 |
| LONG BAY | 480 | 223 | 800,639 | 58,610 | 443.2 | 31.7 |
| S. CAROLINA | 660 | 200 | 711,451 | 34,612 | 284.0 | 13.8 |
| GEORGIA | 480 | 190 | 429,247 | 21,125 | 231.9 | 11.4 |
| FLORIDA | 298 | 180 | 598,306 | 38,276 | 515.1 | 33.0 |
| **SEASON** | | | | | | |
| SPRING | 780 | 210 | 1,248,961 | 97,625 | 409.2 | 32.0 |
| SUMMER | 780 | 213 | 967,689 | 56,347 | 326.9 | 19.0 |
| FALL | 776 | 233 | 1,165,139 | 62,063 | 393.7 | 21.0 |